FORTIFICATION:

OR,

Architecture Military.

Unfolding the

Principal Myſteries thereof;

In the Reſolution of

Sundry QUESTIONS *and* PROBLEMS.

By *RICHARD NORWOOD*,

Reader of the *MATHEMATICKS.*

LONDON:

Printed for *Richard Mount*, at the *Poſtern*, on *Tower-Hill.* 1694.

To the Right Honourable,

James Marqueſſe of *Hamilton*, Duke of *Chartelraot*, Earle of *Cambridge*, and *Arran*, Lord of *Ennerdale*, *Evendale*, *Arbroth* and *Kenile*, Gent. of the Kings Bed-Chamber, and one of his Majeſties moſt Honorable Privy Counſell, Steward of the Honor of *Hampton Court* and *Portſmouth*, Great Maſter of his Maties. horſe, and Knight of the moſt noble Order of the Garter.

Right Honourable,

Conſidering how largely the precepts of *Fortification* are handled by ſundry Authors in other languages, and how little is to be found thereof in our Engliſh tongue: I thought it neither fruitleſſe nor unſeaſonable, to publiſh

theſe collections and obſervations which I had formerly made. Wherein though I chiefly aimed to ſhew the application of the doctrine of *Triangles*, according to that late invention of *Logarithmes*; Yet have I not pretermitted other things neceſſary for the better underſtanding and practiſe thereof. Which I preſume not to preſent unto your Honour for the worth of it; But in reſpect of your Lordſhips knowledge in the *Mathematicks* in generall, and your more ſpeciall experience in *Military* affaires, I am emboldned to crave your Honorable patronage. The Lord of all things and King immortall preſerve your Lordſhip in all happineſſe unto his Heavenly kingdome, So prayeth

Your Honors

in all due obſervance,

Rich. Norwood.

TO THE READER.

When I had written the Doctrine of Triangles, suteable to the late Invention of Logarithmes, I endeavoured to make application thereof in sundry parts of the Mathematickes, *and amongst the rest in* Fortification; *Wherein I used the more diligence, that I might give satisfaction to such as I instructed therein. And this was the principall occasion of compiling this ensuing Treatise, which lying by me certaine yeares, I have beene importuned by some friends to publish for a more common good; whereunto I have the rather yeelded, forasmuch as there is so little extant in our* English *tongue of this subject. I professe not herein any skill extraordinary; but as it is incident to most men in varietie of studdies, to bend themselves more especially to some one: so I confesse, that although by reason of my Calling (teaching the* Mathematickes *in* London) *I have had occasion to apply my selfe to*

the

theſe collections and obſervations which I had formerly made. Wherein though I chiefly aimed to ſhew the application of the doctrine of *Triangles*, according to that late invention of *Logarithmes*; Yet have I not pretermitted other things neceſſary for the better underſtanding and practiſe thereof. Which I preſume not to preſent unto your Honour for the worth of it; But in reſpect of your Lordſhips knowledge in the *Mathematicks* in generall, and your more ſpeciall experience in *Military* affaires, I am emboldned to crave your Honorable patronage. The Lord of all things and King immortall preſerve your Lordſhip in all happineſſe unto his Heavenly kingdome, So prayeth

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TO THE READER.

WHen I had written the Doctrine of Triangles, ſuteable to the late Invention of Logarithmes, I endeavoured to make application thereof in ſundry parts of the Mathematickes, and amongſt the reſt in Fortification; Wherein I uſed the more diligence, that I might give ſatisfaction to ſuch as I inſtructed therein. And this was the principall occaſion of compiling this enſuing Treatiſe, which lying by me certaine yeares, I have beene importuned by ſome friends to publiſh for a more common good; whereunto I have the rather yeelded, foraſmuch as there is ſo little extant in our Engliſh tongue of this ſubject. I profeſſe not herein any skill extraordinary; but as it is incident to moſt men in varietie of ſtuddies, to bend themſelves more eſpecially to ſome one: ſo I confeſſe, that although by reaſon of my Calling (teaching the Mathematickes in London) I have had occaſion to apply my ſelfe to

the

the studdy and exercise of sundry Arts Mathematicall; Yet more especially to the Optickes, and chiefely to that part thereof which handleth the nature and operation of luminous beames by glasses reflected or refracted, drawne thereunto by a more speciall affection or instinct. All which notwithstanding, I have not beene negligent in this subject, having beene sometimes a souldier in my youth, though not long, and seene some experience of these things, though not much; yet that little with some observations of riper yeares which I since made in the Netherlands, hath somewhat furthered me in handling of it. Besides, I have perused sundry Authors, following those chiefely whom I conceive to have shewed the best rules, and more moderne practise of Fortification. I have endeavoured to be so perspicuous as I could in so many words, avoyding prolixity in this first assay, till I have tryed your entertainement. In the meane time not doubting, but many of our Countrymen, as well such as are here resident, as others applying themselves to the furtherance of our many plantations abroad, will courteously accept this mine endeavour. Farewell. London. 1637.

FORTI-

FORTIFICATION OR ARCHITECTVRE *MILITARIE.*

CHAP. I.

BEfore we come to particular Problemes, we will premiſe ſome things of more generall uſe, in all parts of this enſuing Treatiſe, and firſt

The proper and more frequent termes of this Art, in *Engliſh*, *French*, and *Latine*.

A Fort, French, *Fort:* Latine, *Arx*, *fortalitium*, *munitio*. A Fortreſſe, a ſmall Fort, or Caſtle, or Sconce. French *Fortreſſe*, La. *Caſtrum muniticuncula*, *munitio Campeſtris*; theſe names, a Fort and Fortreſſe and many of the reſt following are (as it may appeare) borrowed of the French; ſome make a diſtinction betweene theſe two names, and would have

to be understood by a Fortresse, a little Fort or field Sconce, but others use them promiscuously. The Rampire, this is a wall of Earth enclosing the place fortified, whose foote or foundation is here marked with *a b*. Fre. *Rampart*. Lat. *Vallum*.

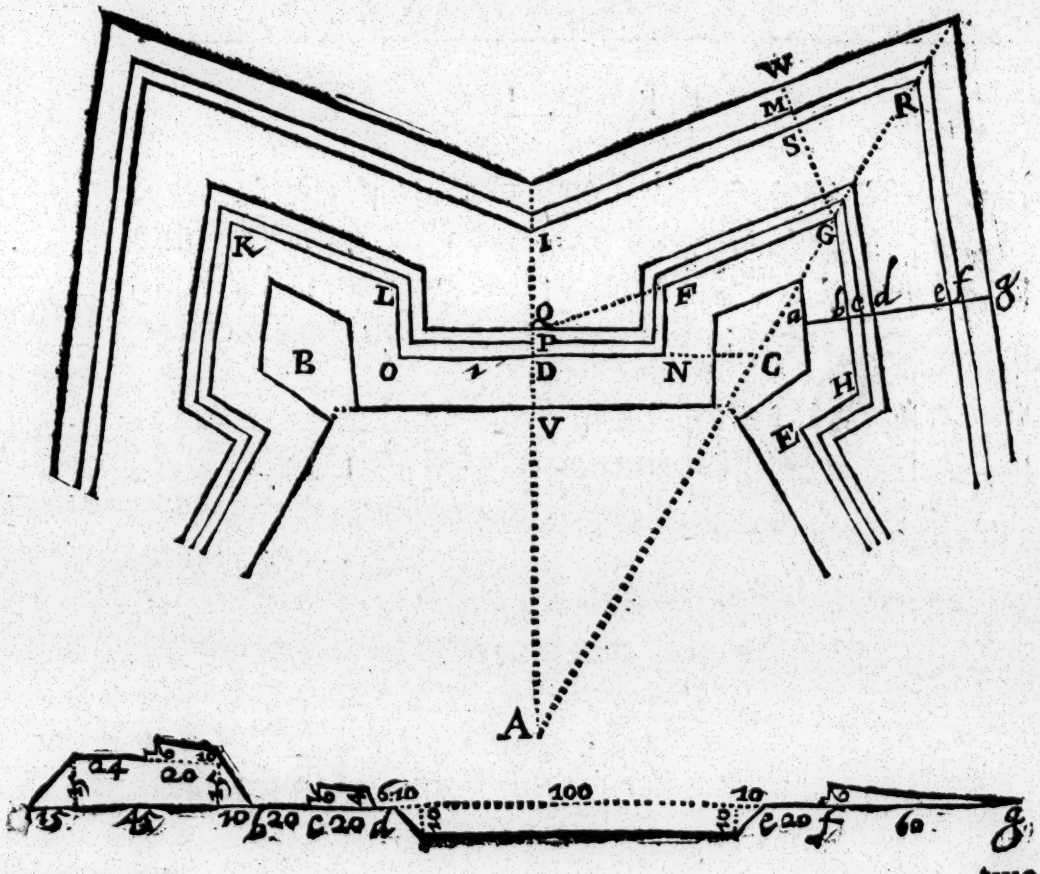
A Curtaine, *O. N.* Fr. *Curtine*, Lat. *Cortina*.

A Bulwarke, *N.F.G.H.E.* Fre. *Bastion*, *Bouleuert*. Lat. *Propugnaculum*.

The Front of the Bulwarke, *F. G.* Fre. *Face*, *pand du bastion*. Lat. *Facies propugnaculi*.

The Flancke, *N. F.* Fre. *le Flanc*. Lat. *Ala*.

The Gorge of the Bulwarke, or the space betweene



two

two flanckes. *N. E.* Fre. *Gorge du baſtion.* Lat. *Collum propugnaculi.*

The Gorge line *N.C.* Fr. *ligne du Gorge.* Lat. *linea Colli.*

The Head-line, *C.G.* Fr. *ligne Capitale.* Lat. *Linea capitalis.*

The Shoulder *F.* Fr, *Eſpaule.* Lat. *Scapula.*

The Diamond point of the Bulwarke, or the flanked angle of the Bulwarke. *G.* Fr. *Angle. flangue.* Lat. *Angulus propugnaculi, ſeu Angulus defenſus.*

The ſecond flanke *O. i.* Fr. ſecond *flanc.* Lat. *Ala Cortinæ.*

The fixing fixed, or longeſt Line of defence *O.G.* Fr. *Ligne de defenſe fichente.* Lat. *Linea defenſionis major.*

The ſhorteſt line of defence ſcowring the front, *i. G.* Fr. *ligne defenſe flanguante.* Lat. *linea defenſionis minor.*

The inward flanking angle, *F. i. N.* Fr. *Angle flanguant interieur.* Lat. *Angulus defenſionis interior.*

The outward flanking angle *K. P. G.* Fr. *Angle flanguant exterieur, ou Angle de tenaille.* Lat. *Angulus defenſionis exterior.*

A *Caſemate.* Fr. *Cazemate.* Lat. *Caſa armata.*

The Parapet as namely of the Rampirē, Fauſebray and Coverat way. Fr. *le Parapet.* Lat. *Lorica.*

The walke on the Rampire. Fr. *Terre-plein.* Lat. *Ambulacrum valli.*

The ſcarpe, inward or outward, as of the Rampire, parapets and ditch. Fr. *Talud interieur ou exterieur,* Lat. *Acclivitas interior vel exterior.*

Palizadoes. Fr. *Paliſsades.* Lat. *Sudes præpilatæ.*

A Banke or Foote-pace. Fr. *Banquet.* Lat. *Scamnum, ſcabellum.*

The Fauſſebray, the breadth whereof is here marked

with *B. C.* Fr. *Chemindes Rondes, Fauſſebray.* Lat. *Spatium horizontale, ſuccinctus.*

The Brimme of the Ditch. Fr. *Liſiere.* Lat. *Margo valli.*

The Ditch, the breadth whereof is here marked with *d. e.* Fr. *le Foſſe.* Lat. *Foſſa.*

The Counterſcarpe. Fr. *Contreſcarpe.* Lat. *Acclivitas foſſæ exterior.*

The Covert way, the breadth whereof is here marked with *e. f.* Fr. *Couridor, au Chemin covert.* Lat. *via Cooperta.*

A Ravelin. Fr. *Ravelin.* Lat. *Moles.*

An Halfe-moone. Fr. *Demi-lune.* Lat. *Luna dimidiata.*

An Horne-worke, Fr. *Ouvrage a Corne.* Lat. *Opus Cornutum.*

A Trench, Fr. *Trenchée.* Lat. *Seps Caſtrorum.*

Gabions, Fr. *Gabions.* Lat. *Corbes terræ.*

A Breach, Fr. *Breche.* Lat. *Ruina valli.*

A myne, Fr. *Mine.* Lat. *Cuniculus.*

A Countermine, Fr. *Contremine,* Lat. *Cuniculus reciprocus.*

Theſe and ſuch other tearmes as are uſed in Fortification will be better underſtood where we have occaſion to ſpeake of them.

The meaſures uſed in this enſuing Treatiſe.

AMong thoſe that write of Fortification, there are ſeverall meaſures uſed, as ſome uſe feete, and that of ſeverall ſizes, ſome Toiſes, a toiſe containing ſixe feete, others verges or rods of 12. feete to a verge, which are now generally uſed in the united Provinces. Wee alſo in *England,* uſe rods or poles of ſeverall ſizes the moſt uſuall of ſixteene feete and an halfe. But of

all others I should choose (as apteſt for this buſineſſe) a Rod of tenne foote, which is alſo often uſed by ſome Architects: For any number of theſe rods are moſt eaſily reduced into feete, and feete into theſe rods, whereof there is often occaſion: Alſo theſe rods are moſt eaſily reduced into paſes, or paces into rods, ſeeing two make a rod; And paces are ſuch a meaſure, as every man doth naturally carry about him, at leaſt to a neere ſcantling, for a man of middle ſtature walking a travailing pace, moves his foot about one pace, or five foot at each remove, a tall man muſt goe ſomething ſlower, and a little man ſomething faſter to doe the like, therefore we will here uſe ſuch rods of tenne feete; and if you make a chaine for this purpoſe, it may conſiſt of five ſuch rods or 50. feete, which is three of our ſtatute poles and halfe a foote over, and if you would uſe ſuch a chaine for our ordinary Land meaſure, you muſt take up halfe a foote, &c. But this we leave, proceeding to the thing in hand.

CHAP. II.

Axiomes obſerved in fortificatien, with the reaſons of them.

1 A Fort is made to the intent that a few men might be able to defend themſelves and the place, againſt a greater number.

2. Therefore the place is environed with a Rampire or wall and a ditch, of ſufficient height breadth and depth, to impeach the aſſaults of an enemie.

3. And becauſe the ſides thus ēncloſing a Fort, ārē not apt for the defence of themſelves, eſpecially when an enemy is neareſt, and ſo the defence moſt neceſſary, therefore the ſides of the Fort have flankers or (as they are commonly called) flankes to defend them, which flankes are alſo themſelves flanked by the Curtaines or ſides; theſe flankes in the foregoing figure are repreſented by, *H. E.* or *F. N.* or *L. O.* &c.

4. And for the better defence of each ſidē or Curtaine, it is requiſite that every ſide of a Fort ſhould have two flankes, namely toward each end one, and if the ſide be very long, it may have foure, ſixe or more; but of their diſtance we ſhall ſpeake hereafter; as of the ſide *B. C.* the two flankes or flankers are *L. O.* and *F. N.*

5. And thus there will bee two flankes placed neare together at every angle or meeting of two ſides, (or oftner if occaſion require) the one ſcowring the ſide towards the right hand, the other towards the left, either of them ſtanding perpendicular to the ſides which they flanke, the diſtance of which two flankes is called the Gorge or necke of the bulwarke. Two ſuch flankes are repreſentēd by *F. N.* and *H. E.* and the Gorge by *N. E.*

6. And becauſe if the wall or Rampire ſhould be continued ſtreight or circuler, betweene the ends of every of theſe two flankes, thus placed on either ſide of the Gorge (as from *F.* to *H.*) that wall could not be defended from the flankes, neither is apt for the defence of it ſelfe: therefore the two Fronts of each bulwarke, are drawne with ſuch inclination, that they might aptly bē ſcoured, and defended from their correſpondent flankes. As the Fronts *F. G.* and *G. H.*

7. And ſeeing the Curtaines and Fronts of a Fort arē eſpecially defended, (both with Ordinance and ſmall ſhot)

ſhot) from the Flankes, and that the aſſailants will ſooneſt attempt to make a breach by battery or otherwiſe in or about the flanked angle of the bulwarke: therefore the greater and more ſpacious, the flankes and the Gorge betweene them are (with due conſideration of other things conſiderable) the better they are.

8. And foraſmuch as the front of a bulwarke needes the more defence for that it lyes fartheſt from the flanke defending it, &c. therefore it is ſo to be drawne that it may be defended by ſhot from as great a part of the Curtaine as conveniently may be, which part of the Curtaine is called the ſecond flanke; thus in the foregoing figure the ſecond flanke is repreſented by *O.i.*

9. The outward flanking angle muſt not be too obtuſe namely it ſhould never exceede 150. degrees, but by how much leſſe it is, ſo much the better: for by this meanes, the fronts of the bulwarkes, are the better flanked, the one by the other, &c.

10. And for theſe two cauſes chiefely, the angle of the outward or diamond point of a bulwarke ſhould not be greater then 90 degrees. As the angle, *F.G.H.*

11. Yet conſidering that by how much the more acute that angle of the bulwarke is, ſo much the weaker it is to withſtand a battery, and that the aſſaults of an enemy by battery are often made againſt that eſpecially: therefore that angle muſt never be too acute, namely never leſſe than 60. degrees and by how much nearer to a right angle, the better it is. *Errard Barleduc* and ſome others would have it alwayes a right angle, but by the common practiſe in the Netherlands, grounded upon ſufficient reaſons, it is often made leſſe.

12. And for the reaſon aforeſayd, the angular point of the figure whereon a bulwarke is to be placed, ſhould

not

not be leſſe then a right angle, but by how much the more obtuſe, ſo much the better it is. As the angle *B. C. X.*

13. The inward flancking angle, and the angle of the ſhoulder of the bulwarke, encreaſe and decreaſe together, the one alwayes exceeding the other 90 degrees; and therefore as the inward flanking angle ſhould never be leſſe then 15. degrees, ſo the angle of the ſhoulder muſt never be leſſe then 105 degrees, and by how much greater, the better, for the ſame reaſons, as are before alleadged. The inward flanking angle is, *F. i. N.* The angle of the ſhoulder, *G. F. N.*

14. The fixed or longeſt line of defence drawne from the angle of the flanke to the outward angle of bulwarke ſhould not exceede 720. foote or 72. rodds that ſo it may not be without musket ſhot, that being an Engine more portable, and ready for defence then great peeces, which effect nothing but with more loſſe of time, and other inconveniences. Yet if you will defend the front with Cannon, then may that line be almoſt twice ſo much; As a line drawne from *O* to *G.*

15. And for as much as in a regular Fort the force is in all parts more equall and alike; and that it doth enclofe a greater quantity of ground, then an Irregular Fort of ſo many ſides: therefore a regular Fort (if the place will conveniently admit of it) is better then an Irregular.

It is called a regular Fort, when the figure fortified conſiſts of equall ſides and angles.

16. By that which hath beene ſayd, eſpecially by the twelfth axiome, it is evident, that a Fort of three ſides, and angles is of no moment, neither is a Fort of foure ſides of any great value, but in generall the more ſides

and

and angles a Fort hath, the better it is.

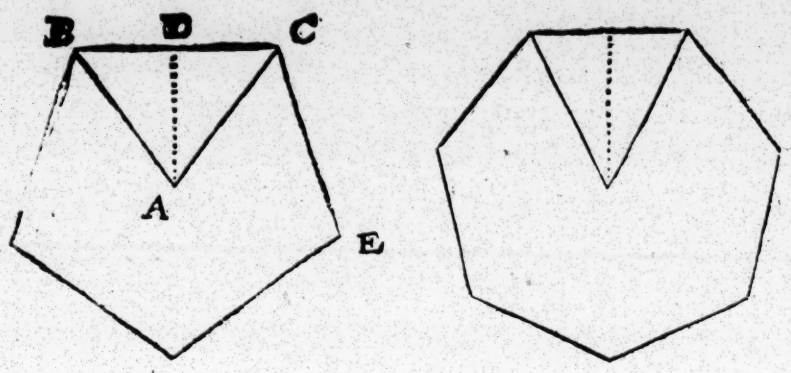
17. If the fixed line of defence be 720 foote or 72 roods then may the Curtaine be about 42 rods; the front of the bulwarke may be about 28 rods; and the angle forming the flanke about 40 degrees, and the flanke to the Gorge as 6. to 7. But if the figure you would fortifie be lesse, you may diminish the gorges, flankes, and fronts, proportionally retaining the angles sutable to these Axiomes, and hereafter more particularly expressed. And in fortifying any place, regular or irregular, you are to observe (so neere as may be) these Axiomes, and the reasons of them together with the Problemes and examples, hence deduced, and hereafter set downe. The angle forming the flanke is *F.C. N.*

CHAP. III.

Probleme. I.

TO finde the quantity of the angle, at the Center or perimeter of any regular poligon and the number of inhabitants whereof a fort is capable as in this figure, following let *B C.* be the side of an Equilaterall pentagon

There is required the angle at the Center *B. A. C.* and the angle at the perimeter, *B. C E.* Divide the circumference of a circle, 360. degrees, by the number of the sides of the poligonon, 5. the quotient is the angle at the Center, *B. A. C.* 72. degrees. which substracted from 180. degrees, there remaines the angle at the



perimeter, *B. C. E.* 108. degrees.

The reaſon of the firſt part of this operation is manifeſt, and touching the ſecond, ſeeing the th ee angles of the triangle, *A. B. C.* are equall to 180. degrees therefore from 180. degrees ſubſtracting the angle *B. A. C.* there remaines the ſum of the angles *A. B. C.* and *A. C. B.* which two being ſeverally the half of the angles at *B.* and *C.* are together eq all to the angle *B. C. E.*

Probleme. 2.

The Quantity of one of the ſides given: to finde the ſemidiameter of the circumſcribed Circle, and the perpendiculer to that ſide and ſo the area or quantity of ground in that figure.

AS in the foregoing figure, let the ſide of a pentagonall Fort *B. C.* be after the *Italian* manner 800. foote, then is the halfe thereof *B. D.* 400. foote, and the angle at the center, *B. A. C.* 72. degrees, the halfe whereof is *B. A. D.* 36. degrees. and the complement thereof *D. B. A.* 54 degrees, therefore by the firſt caſe of plaine ttiangles,

As

As *Radius* is in proportion		
to halfe the ſide given	*BD*. 400. foote 2,	6020600.
ſo tang halfe the angle at the perimeter	t *ABC* 54-06. 10,	1387390.
to the perpendiculer	*AD* 550. 55, 2,	7407990.

And by the ſecond caſe of plaine triangles,

As ſine halfe the angle at the center	s *BAD* 36--06 ,	2307813.
to halfe the ſide given	*BD* 400. foote 2,	6020600.
So is *Radius*		
to the ſemidiameter of the Poligon	*AB*, 680. 52--2,	8328413

This ismore properly the ſemidiameter of the circumſcribed circle which for brevity ſake we call here and hereafter the ſemidiameter of the poligonon.

This perpendiculer	*AD* 550. 55. 2,	7407990.
multiplyed by halfe the baſe	*BD*. 400. .2,	6020600.
produceth the area of the triangle	*ABC*. 220221. 5,	3428590.
which multiplyed by the number of ſides	. 5.	0,6989700.
produceth the area of the poligonon	*1101105.f	6,0416260.

Note. The operations here or hereafter uſed by logarithmes whether in the reſolution of triangles or in multiplication, diviſion, extraction of rootes or the rule of proportion I have ſufficiently handled in my firſt booke of plaine triangles which therefore it were ſuperfluous here to repeate, the fractions here and hereafter uſed are decimals namely tenth or hundreth parts: ſo that if there be one figure behind the pricke it ſignifies tenths as 351. 2 is $351\frac{2}{10}$. ſo 550. 55. is $550\ \frac{55}{100}$.

Probleme. 3.

To finde what number of inhabitants a Fort is capable of.

IT is to be understood that within the poligon figure caſt up as we have ſhewed in the laſt Probleme, there is the Rampire, the ſtreets, the Market place, and the reſidue for the inhabitants; now the Rampire, ſtreets & Market place may be the halfe or third part of the area of the poligon figure, ſometimes more ſometimes leſſe, and that being ſubſtracted the reſidue (as I ſay) is for the inhabitants. We will take for example the ſeven ſided Fort expreſſed hereafter in the 11. Chapter.

I devide the circumference of a Circle, 360. deg.
by the number of ſides which is 7.
the quotient is the angle at the Center *BAC.* 51. 25 $\frac{1}{7}$.
which ſubſtracted from 180. deg.
remaine the angle at the perimeter *BCE.* 128. 34 $\frac{2}{7}$.
And ſuppoſing the ſide of the poligon namely the curtaine with the two Gorge-lines to be 702. 4.

Then will the perpendiculer be found by the laſt Probleme to be about 729. foote, ſo that the area of the triangle *B. A. C.* will be 256025. ſquare feete and ſeeing the figure hath 7. ſides therefore the area of the whole poligon figure is 1792175. ſquare feete, Now we ſuppoſe the Rampire to be there 70 foote broade, and the ſtreete or way next within the Rampire 40. foote, both are 110. foote which ſubſtracted from the foreſayd perpendicular 729. there remaines a perpendiculer, 619. then foraſmuch as like poligon figures are in double the proportion of their proportionall ſides, therefore

therefore

As the ſquare of the perpendiculer 729 { 7,1372725. / 7,1372725.

To the ſquare of the perpendiculer 619 { 2,7916906. / 2,7916906.

So is the firſt area 1792175. .6,2533800.

to the ſecond area 1292130. .6,1113062.

Or if you rather deſire to work by triangles then ſuppoſing the perpendicular to be *A. D.* 619. you muſt finde halfe the ſide *B. D.* ſaying

As *Radius* is in proportion

to the perpendicular *AD.* 619. 2,7916906.

ſo tan. halfe the an. ath' cen. *t BAD.* 25 42. $\frac{6}{7}$ 9,6828270.

to halfe the ſide, *BD.* 298. 21. 2,4745176.

which mult. by the perp. *AD.* 619. .2,7916906.

produceth the area of *BAC.* 184590. 5,2662082.

Which againe multiplyed by he ſides 7. 0,8450980.

produceth the 2d area 1292130. .6,1113062.

And ſo much is this heptagon within the Rampire, and the ſtreete going round within the Rampire.

Next for the Market place, the ſide thereof being 170. foote.

As halfe the ſide of the Fort, 351. 2. .7,4544455.

to halfe the ſide of the Market pla. 85. . .1,9294189.

ſo is the perpend. of the Fort 729. . .2,8627276.

to the perp. of the Market place 176.44. .2,2465920.

which multip. by halfe the ſide 85. . .1,9294189.

and that againe by all the ſides 7. . .0,8450980.

prod. the area of the Market pla. 104982. 5,0211089.

and ſeeing the one perpendiculer is 619. foote.
and the other of the Market place 176.44.
the difference of theſe two is 442.56.

Being the diſtance from the Market place, to the ſtreete next under the Rampire,

which multiplyed by the breadth . 30. foote.
produ. the area of one of thoſe ſtreets . 13276.80.
which multipl. by the number of ſides 7.
produceth the area of all thoſe ſtreets . 92937.

Laſtly for the middle ſtreete that goeth round about betweene the Rampire and the Market place.

Let us ſuppoſe in this example the perpendiculer diſtance of that ſtreete from the center of the Market place to be 42 rods, (I meane from the center of the Fort to the middle line of that ſtreete) then for a ſeaventh part of the middle perimeter or compaſſe of that ſtreete I ſay.

As the firſt perpendiculer	729. foote.	. . 7,	13727.5.
to this perpendiculer,	410. foote.	. . 2,	6232493.
ſo the firſt ſide,	702.	4. . . 2,	8465845.
to this ſecond ſide	404.	67. . . 2,	6071063.
which multiplyed by	7.		0 8450980.
prod. the compa. of that ſtreet	2832.	7.	3,4522043.
which mul. by the breadth	30.		1,4771213.
prod. the area of that ſtreet,	84982.		4,9293256.
and the area of the other 7. ſtr.	92937.		
and the area of the market place,	104982.		
The ſumme of theſe three	282901.	ſquare feete.	
ſubſtr. from the before found	1292130.		
there remaines	1009229.	ſquare feete.	

Thus

Thus then the heptagon to be fortified containes as before wee found 1792175. ſquare feete, but within the Rampire and the ſtreete or way next within the Rampire it containes but 1292130 ſquare feete whereof the ſtreetes and market place, amount to 282901. ſquare feete which deducted there remaines for the houſes and other accommodations of the inhabitants, 1009229. ſquare feete that is 10092 rods and 29 feete ſquare. Now we may aſigne for every houſe 10 ſquare rods or 1000. ſquare feete, or ſomething more or leſſe as the preſent occaſion ſhall require; and ſo this place is capapable of 1009 houſhoulds for deviding 1009229 feete by 1000, or 10092 rods by 10, the quotient in either is 1009. beſides the fraction which here we regard not.

CHAP. IIII.

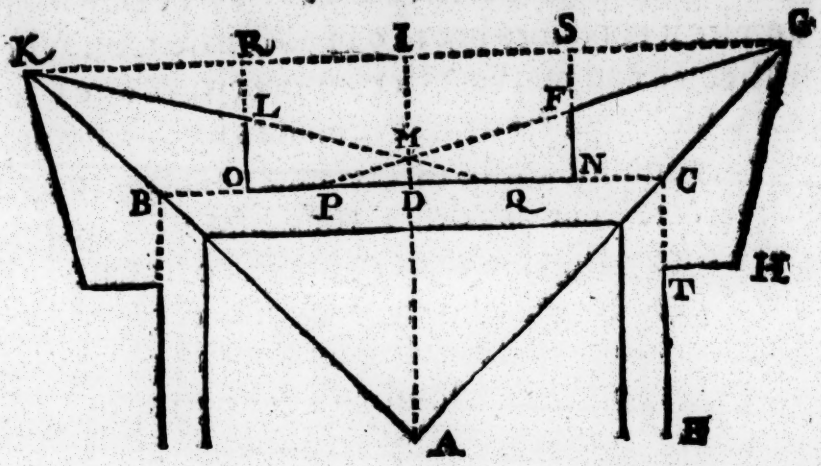
To finde the quantity of the angles in all parts of a Fort of any number of ſides propoſed.

BY the ſixteenth Axiome, a Fort is to conſiſt of at leaſt foure ſides, and by the eleventh Axiome, the flanked angle of a bulwarke ought to be at the leaſt 60. degrees, therefore in a regular Fort of foure ſides, the flanked angle of each bulwarke ought to be 60. degrees, and conſequently the outward flanking angle muſt needes be 150 degrees.

As in this figure let *B. C.* be one ſide of a ſquare fortified with foure bulwarkes, one of which let bee

N.F.G.

N.F.G.H.T. And seeing the flanked angle of this bulwark *F.G.H.* is 60. degrees, therefore the halfe thereof



F.G.C. is 30. degrees, and *I.G.C.* (being equall to *D.C.A.* namely halfe the angle of the tetragon) is 45. degrees, therefore *S.G.F.* is 15. degrees, and the complement thereof *S.F.G.* 75. degrees, whereto is equall the angle *I.M.G.* which is the halfe of *K.M.G.* therefore the outward flanking angle, *K.M.G.* is 150. degrees, which was to be proved.

And thus in a quadrangular Fort, the flanked angle is 60. degrees, and the outward flanking angle 150. degrees; what theſe angles will be in other Forts conſiſting of more ſides we may finde by helpe of theſe thus.

Subſtract the angle of the ſquare namely 90. degrees from the angle of the poligonon propoſed, halfe the remainer adde to the flanked angle of the ſquare that is to 60. degrees, and ſo you have the flanked angle of the poligon propoſed: Alſo ſubſtract the foreſayd halfe remainer from the flanking angle of the ſquare, namely from 150. degrees, and that which remaines is the flanking angle of the poligonon propoſed.

1. *Example of a Pentagon.*

The angle at the perimeter is	180. d.
from which subſtr. the angle of the ſquare,	90.
there remaines	18.
the halfe whereof	9.
added to the flanked angle of the ſquare	60. d.
gives the flanked angle of the pentagon	69.
And from the flanking angle of the ſquare,	150. d.
ſubſtracting the aforeſayd	9.
remaines the flanking angle of the pentagon,	141.

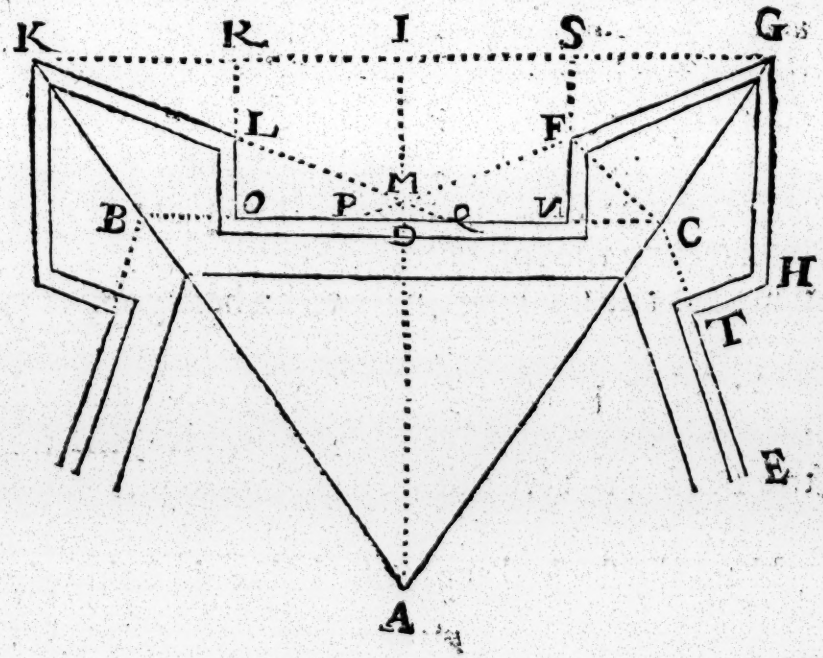
2. *Example of a Hexagon.*

From the angle of the hexagon being,	120. d.
ſubſtract the angle of the ſquare,	90.
and there remaines	30.
the halfe whereof	15.
added to the flanked angle of the ſquare,	60.
makes the flanked angle of an hexagon,	75.
and from the flanking angle of the ſquare	150.
ſubſtracting the foreſayd,	15.
remaines the flanking angle of an hexagon,	135.

And thus proceeding in the uſe we ſhall finde that the flanked angle will not be 90. degrees, till we come to a Fort of twelve ſides.

Now the flanked angle of a bulwarke being given we may thereby come to the knowledge of all the other angles requiſite to be knowne,

As in this figure let *B C* be the ſide of a Pentagon, whoſe		
angle at the Center is (by the 1. ch.	*B A C.* 72.	d. 00.
the half whereof is	*C A D.* 36.	00.
the complement thereof,	*D C A.* 54.	00.
now admit the angle of the bulwark,	*F G H.* 69.	00.
the halfe thereof	*F G C.* 34.	30.
ſubſtracted from *S G C* being equall to	*D C A.* 54.	00.
remaines the inward flanking angle	*S G F.* 19.	30.
equall to *F P N* the compl. of either	*S F G.* 70.	30.
ſubſtracted from two right angles,	180.	00.
leaves the angle of the ſhoulder	*N F G.* 109.	30.
Againe the ſame angle *S F G* or	*I M G.* 70.	30.
doubled, gives the outward flan. ang.	*K M G.* 141.	00.
Laſtly from two right angles,	180.	00.
ſubſtr. half the angle of the poligon,	*B C A.* 54.	00.
remaines the angle,	*D C G.* 126.	00.



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0	40	50
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0	36	40
0	34	35
0	32	30
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0	26	15
0	24	10
0	22	5
0	20	0
0	18	55
0	16	50
0	14	45
0	12	40
0	10	35
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0	6	25
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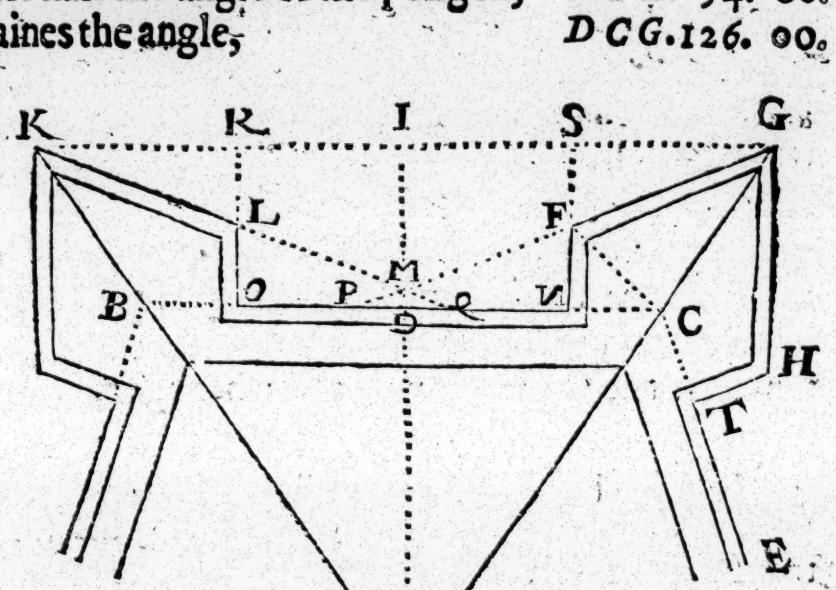
As in this figure let *B C* be the side of a Pentagon, whose

angle at the Center is (by the 1. ch.	*B A C.* 72.	d. 00.
the half whereof is	*C A D.* 36.	00.
the complement thereof,	*D C A.* 54.	00.
now admit the angle of the bulwark,	*F G H.* 69.	00.
the halfe thereof	*F G C.* 34.	30.
subſtracted from *S G C* being equall to	*D C A.* 54.	00.
remaines the inward flanking angle	*S G F.* 19.	30.
equall to *F P N* the compl. of either	*S F G.* 70.	30.
subſtracted from two right angles,	180.	00.
leaves the angle of the ſhoulder	*N F G.* 109.	30.
Againe the ſame angle *S F G* or	*I M G.* 70.	30.
doubled, gives the outward flan. ang.	*K M G.* 141.	00.
Laſtly from two right angles,	180.	00.
ſubſtr. half the angle of the poligon,	*B C A.* 54.	00.
remaines the angle,	*D C G.* 126.	00.



And

A Table of the dimensions of the angles observed in fortifying any regular Poligon from the Square, to a figure of 12. sides, so increasing that the flanked angle thereof is a right angle.

Poligons the number of their sides	4	5	6	7	8	9	10	11	12
	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.
Angle at the Center —— BAC.	90	72	60	51 3/7	45	40	36	32 8/11	30
Angle of the Poligon —— BCE.	90	108	120	128 4/7	135	140	144	147 3/11	150
Halfe the angle of the poligon —— BCA.	45	54	60	64 2/7	67 1/2	70	72	73 7/11	75
Hereunto adde ——	15	15	15	15	15	15	15	15	15
The flanked angle —— FGH.	60	69	75	79 2/7	82 1/2	85	87	88 7/11	90
Halfe the flanked angle —— FGC.	30	34 1/2	37 1/2	39 9/14	41 1/4	42 1/2	43 1/2	44 7/22	45
Inward flanking angle FPN. *or* SGF.	15	19 1/2	22 1/2	24 9/14	26 1/4	27 1/2	28 1/2	29 7/22	30
Which added to a right angle ——	90	90	90	90	90	90	90	90	90
Angle of the shoulder —— NFG.	105	109 1/2	112 1/2	114 3/14	116 1/4	117 1/2	118 1/2	119 7/22	120
Angle opposite to the head-line GFC.	55	59 1/2	62 1/2	64 5/14	66 3/4	67 1/2	68 1/2	69 7/22	70
Angle opposite to the front —— FCG.	95	86	80	75 5/7	72 1/2	70	68	66 4/11	65
The complement of SGF. *namely* SFG.	75	70 1/2	67 1/2	65 5/14	63 3/4	62 1/2	61 1/2	60 15/22	60
The outward flanking angle —— KMG.	150	141	135	130 5/7	127 1/2	125	123	121 4/11	120
The angle forming the flanke —— FCN.	40	40	40	40	40	40	40	40	40

Place this after fol. 19.

But if you would have the flanked angle of the Bulworke ſo to en
creaſe, that for an Octagon it might be a right angle, then make th
flanked angle, two third parts of the angle of the poligon propoſed
as is done in the Table following, but for any poligon of abov
eight ſides, let the flanked angle be a right angle.

A Table of the dimenſions of the angles obſerved in Fo tifying any Regular Poligon from the Tetragon to the Octagon, ſo increaſing that the flanked angle of the Octagon is a right angle.

Poligons the number of their ſides	4	5	6	7	8
	deg.	deg.	deg	deg.	deg.
Angle at the Center —— BAC.	90	72	60	51 3/7	45
halfe the angle at the Center — IAG.	45	36	30	25 5/7	22 1/2
the angle of the Poligon —— BCE.	90	108	120	128 4/7	135
the flanked angle —— FGH.	60	72	80	85 5/7	90
halfe the angle of the Poligon — BCA.	45	54	60	64 2/7	67 1/2
halfe the flanked angle —— FGC.	30	36	40	42 6/7	45
the inward flanking angle —— SGF.	15	18	20	21 1/7	22 1/2
to which adding a right angle ——	90	90	90	90	90
the angle of the ſhoulder —— NFG.	105	108	110	111 3/7	112 1/2
the angle oppoſite to the head-line GFC.	55	58	60	61 [illegible]	62 1/2
the angle oppoſite to the front — FCG.	95	86	80	7[illegible]	72 1/2
the compl. of SGF. *namely* — SFG.	75	72	70	6[illegible]	67 1/2
the outward flanking angle — KMG.	150	144	140	1[illegible]	135
the angle forming the flanke — FCN.	40	40	40	4[illegible]	40

And thus for any flanked angle propoſed wee may finde the quantities of every of the other angles.

But for any poligon propoſed wee may more compendiouſly ſet downe the angles of the bulwarkes and all the other angles after the forme of this example following, remembring that if the poligon have more than 12. ſides, you make the angle of the bulwarke a right angle.

		d.
To half the angle of the poligon	*B C A.*	54. 00.
adde alwayes		15. 00.
the ſumme is the flancked angle	*F G H.*	69. 00.
the halfe whereof	*F GC.*	34. 30.
ſubſtr. from half the angle of the polig.	*B C A.*	54. 00.
leaves the inward flanking angle,	*S G F.*	19. 30.
whoſe complement is	*S F G.*	70. 30.
which ſubſtracted from two right angles,		180. 00.
leaves the angle of the ſhoulder	*G F N.*	109. 30.
and the ſame complement *S F G* or	*I M G.*	70. 30.
doubled is the outward flanking angle.	*K M G.*	141. 00.

The angle forming the flanke, namely the angle *F. C. N.* may be alwayes about 40 degrees. And according to this rule is the table following made.

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angle, two third parts of the angle of the poligon propoſe
ne in the Table following, but for any poligon of abo
les, let the flanked angle be a right angle.

le of the dimenſions of the angles obſerved in Fo
ying any Regular Poligon from the Tetragon
to the Octagon, ſo increaſing that the flanked angle
of the Octagon is a right angle.

the number of their ſides	4	5	6	7	8
	deg.	deg.	deg	deg.	deg
at the Center —— BAC.	90	72	60	51 3/7	45
angle at the Center —— IAG.	45	36	30	25 5/7	22
le of the Poligon —— BCE.	90	108	120	128 4/7	13
ked angle —— FGH.	60	72	80	85	
angle of the Poligon — BCA.	45	54	60	64	
flanked angle —— FGC					

And thus for any flanked angle propoſed wee may finde the quantities of every of the other angles.

But for any poligon propoſed wee may more compendiouſly ſet downe the angles of the bulwarkes and all the other angles after the forme of this example following, remembring that if the poligon have more than 12. ſides, you make the angle of the bulwarke a right angle.

		d.
To half the angle of the poligon	*B C A.*	54. 00.
adde alwayes		15. 00.
the ſumme is the flancked angle	*F G H.*	69. 00.
the halfe whereof	*F GC.*	34. 30.
ſubſtr. from half the angle of the polig.	*B C A.*	54. 00.
leaves the inward flanking angle,	*S G F.*	19. 30.
whoſe complement is	*S F G.*	70. 30.
which ſubſtracted from two right angles,		180. 00.
leaves the angle of the ſhoulder	*G F N.*	109. 30.
and the ſame complement *S F G* or	*I M G.*	70. 30.
doubled is the outward flanking angle.	*K M G.*	141. 00.

The angle forming the flanke, namely the angle *F. C. N.* may be alwayes about 40 degrees. And according to this rule is the table following made.

CHAP. V.

Of the quantitie of the Curtaines, Flankes, Fronts, Gorges, and other ſides and lines in regular Forts of any number of ſides propoſed.

IT is not of neceſſity that the angles in Forts ſhould be exactly ſuch as are found and ſet downe by the foregoing Rule, but they may be ſomething more or leſſe, as the place or other occaſions ſhall require: But firſt ſuppoſing them to be ſuch, we will ſhew how to determine the quantity of the ſides and lines of a Fort accordingly both by examples and tables for that purpoſe.

PROBLEME. I.

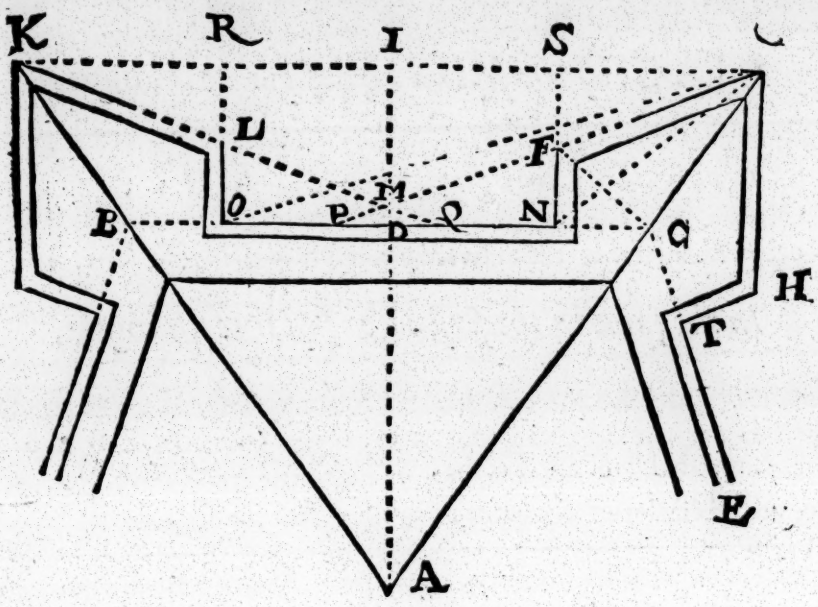
The length of the Curtaine, and of the Front of the Bulwarke given, to finde what the other ſides and lines ſhould be.

AS in this regular Pentagonall Fort, and ſo in others, to the intent the line of defence may be about 72. rods the Curtaine may be about 42. rods and the Front about 28. as is before noted in the 17 Axiome. And that the proportion of the flanke to the Gorge may bee about 6. to 7. let the angle forming the flanke bee 40. degrees.

Thus then the Curtaine is *O N*. 420. foote.
the Front of the Bulwarke *F G*. 280. foote.

And

And the angle forming the Flankē *F C N.* 40. dēg.
And let the Flanked angle be *F G H.* 69. deg.



Then will the other angles be found by the firſt rule of the foregoing chapter to be ſuch as are expreſſed in the former of the two tables: but the ſides we finde thus.

In the right angled triangle* SGF. *by* 3. *caſe of plaine triangles I ſay.

As *Radius* is in proportion to the front of the Bulwarke	*F G.* 280 feete	2,44715.
ſo ſine the inward flanking angle	*s. S G F.* 19. deg. 36.	9 52350.
to the line	*S F.* 93. 47.	1,97065.

Againe by the ſame.

As *Radius* is in proportion to the front of the bulwarke	*F G.* 280. feete.	2,44715.
ſo ſine compl. the inward flanking angle	*s. c. S G F.* 19. deg. 30.	9,97435.
to the line	*S G.* 263. 94.	2,42150.
Whereto adding halfe the Curtaine	*S I.* 210.	

CHAP. V.

Of the quantitie of the Curtaines, Flankes, Fronts, Gorges, and other ſides and lines in regular Forts of any number of ſides propoſed.

IT is not of neceſſity that the angles in Forts ſhould be exactly ſuch as are found and ſet downe by the foregoing Rule, but they may be ſomething more or leſſe, as the place or other occaſions ſhall require: But firſt ſuppoſing them to be ſuch, we will ſhew how to determine the quantity of the ſides and lines of a Fort accordingly both by examples and tables for that purpoſe.

PROBLEME. I.

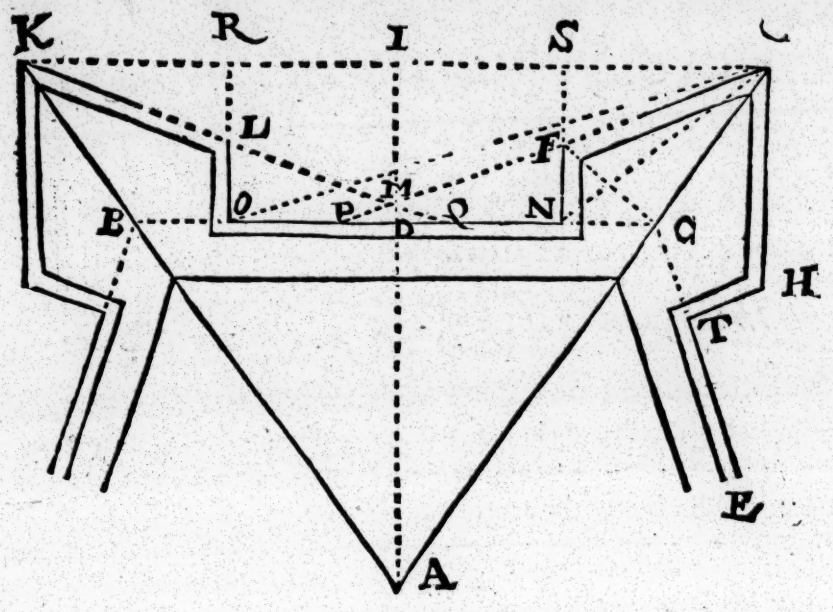
The length of the Curtaine, and of the Front of the Bulwarke given, to finde what the other ſides and lines ſhould be.

AS in this regular Pentagonall Fort, and ſo in others, to the intent the line of defence may be about 72. rods the Curtaine may be about 42. rods and the Front about 28. as is before noted in the 17 Axiome. And that the proportion of the flanke to the Gorge may bee about 6. to 7. let the angle forming the flanke bee 40. degrees.

Thus then the Curtaine is *O N*. 420. foote.
the Front of the Bulwarke *F G*. 280. foote.

And

And the angle forming the Flankē *F C N.* 40. dēg.
And let the Flanked angle be *F G H.* 69. deg.



Then will the other angles be found by the first rule of the foregoing chapter to be such as are expressed in the former of the two tables: but the sides we finde thus.

In the right angled triangle SGF. *by 3. case of plaine triangles I say.*

As *Radius* is in proportion
to the front of the Bulwarke ——— *F G.* 280 feete 2,44715.
so sine the inward flanking angle ——— *s. S G F.* 19. deg. 36. 9 52350.
to the line ——— *S F.* 93. 47. 1,97065.

Againe by the same.

As *Radius* is in proportion
to the front of the bulwarke ——— *F G.* 280. feete. 2,44715.
so sine compl. the inward flanking angle — *s. c. S G F.* 19. deg. 30. 9,97435.
to the line ——— *S G.* 263. 94. 2,42150.
Whereto adding halfe the Curtaine ——— *S I.* 210.

the ſumme is the line ——— *IG.* 473: 94.
which doubled is the ſide of the outward poligonon, or the diſtance of diamond points of the bulwarkes ——— *KG.* 947. 88.

In I A G. *by the ſecond caſe of plaine triangles.*

As ſine halfe the angle at the Center ——— *s. IAG.* 36. d. 06. ,23078.
to halfe the ſide of the outward pentagon ——— *IG.* 473.94. 2,67572

So is *Radius* in proportion
to the Semidiameter of the outward pentagon — *AG.* 806.31. 2,90650

In the ſame by the firſt caſe of plaine triangles.

As ſine halfe the angle at the Center ——— *s. IAG.* 36. d. 06. ,23078.
to ½ the ſide of the outward pentagon ——— *IG.* 473. 94. 2, 67572.
ſo ſine compl. halfe the angle at the Center — *s. c. IAG,* 36. 00. 9, 90796.
to the perpendicular of the outward
pentagon ——— *AI.* 652. 32. 2, 81446.

In F C G. *by the eighth caſe of plaine triangles.*

As the ſine of the angle ——— *s. FC. G.* 86. d. 06. ,00106.
is in proportion to the Front — ——— *FG.* 280. —— 2, 44715.
ſo ſine halfe the flanked angle ——— *s. FGC.* 34. 36. 9,75313.
to the line ——— *FC.* 158.98. 2, 20134.

In the ſame triangle F C G. *by the ſame caſe.*

As the ſine of the angle —— ——— *s. FCG.* 86. d. 06. 1, 00106.
is in proport. to the front ——— — *FG.* 280. ——— 2, 44715.
ſo is the ſine of the angle ——— —— *s. GFC.* 59. 36. 9, 93532.
to the head line ——— ——— *CG.* 241. 84. —— 2, 38353.
which ſubſtracted from the ſemidiam. —— *AG.* 806. 31.
there remaines the ſemidiameter
of the inward pentagon ——— ——— *AC.* 564. 47.

In the triangle F C N. *by the third caſe.*

As *Radius* is in proportion
to the line before found ——— *FC.* 158. 98. —— 2, 20134.
ſo ſine the angle forming the flanke —— *s. FCN.* 40. 06. —— 9, 80807.
to the flanke ——— ——— *FN.* 102. 19. 2, 00941.

whereto

whereto adding the line first found ——— S F. 93. 47.
we have the distance of the pentagons S N or — I D. 195. 66.
which substracted from the perpendicular ——— A I. 652. 32.
there remaines the perpendicular of the
inward pentagon ——— A D. 456. 66.

In the triangle F N C *by the third case.*

As *Radius* is in proportion
to the line before found ——— F C. 158. 98. 2, 20134.
so sine compl. the angle forming the flanke — s. c. F C N. 40. d. 00 9 88425.
to the Gorge line ——— N C. 121. 78. 2, 08559.
whereto adding halfe the Curtaine ——— D N. 210.
we have the line ——— D C. 331. 78.
which doubled is the side of the inward
pentagon ——— B C. 663. 56.

In the triangle F P N. *by the first case.*

As sine the inward flanking angle ——— s. F P N. 19. d. 36. — 47650.
is in proportion to the flanke ——— F N. 102. 19. — 2, 00941.
so sine compl. the inward flank. angle — s. c. F P N. 70. 36. — 9, 97435.
to the line ——— P N. 288. 58. — 2, 46026.
which substract from the Curtaine ——— O N. 420.
remaines the second flanke ——— O P. 131. 42.

In the triangle R O G. *by the fifth case.*

To the line before found ——— S G. 263. 94.
Adding the Curtaine ——— O N. 420.
we have the line ——— R G. 683. 94.

First.

As the line R O or ——— I D. 195. 66. 7, 70850.
is to that line ——— R G. 683. 94. 2, 83502.
so is *Radius* in proportion
to the tang. of the angle ——— t. R O G. 74—62. 10, 54352

Secondly.

As the sine of that angle ——— s. R O G. 74. d. 62 — 01709.
is in proportion to the line ——— R G. 683. 94. — 2, 83502.
so is *Radius* in proportion
to the longest line of defence ——— O G. 731. 4. — 2, 85211.

In

In like ſort we might finde the diſtances D M. P M *&c.*

Touching the fractions in this and all other examples they are as we have before ſayd decimall ſo as the number before the pricke ſignifies ſo many integers, the figure behind the pricke, ſo many tenths of a unite as 711. 4. *laſt before ſignifies* 711 $\frac{4}{10}$ *feete, ſo* 711. 41. *ſignifies* 711 $\frac{41}{100}$ *and the like is to be underſtood of all others.*

2. *Example.*

In the ſame pentagonall figure, let theſe parts be as before,
namely the Curtaine ——— *O N.* 420. foote.
the front of the bulwarke ——— *F G.* 280.
the angle forming the flanke ——— *F C N.* 40.d.
and let the flanked angle of the bulwarke be ——— *F G H* 72.d.

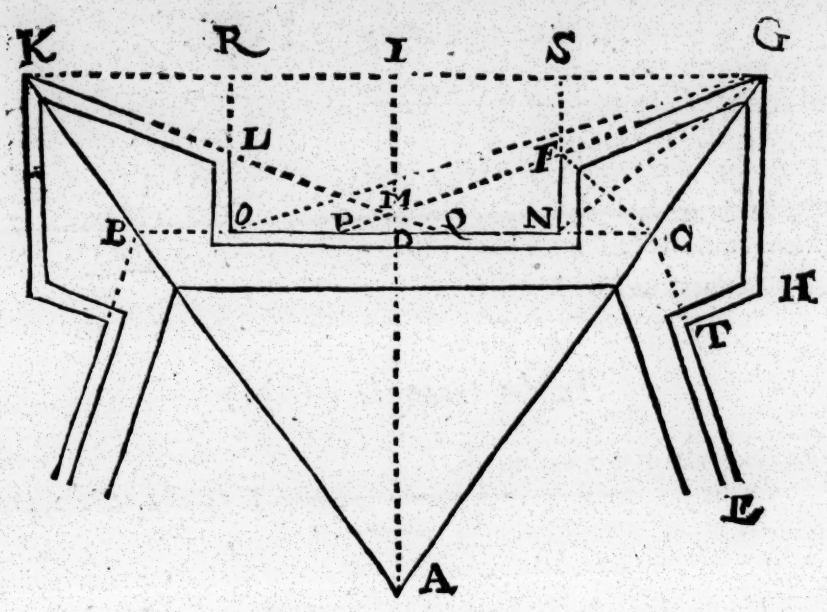
Then will the other angles be found by the ſecond rule of the foregoing chapter to be ſuch as are there expreſſed in the latter of the two tables, and the ſides we finde as before, in the triangle S G F.

As *Radius* is in proportion
to the front of the bulwarke ——— *F G.* 280. foote. 2, 44715.
ſo ſine the inward flanking angle ——— *s. S G F.* 18.d.60. 9, 48998.
to the line ——— *S F.* 86.52. 1, 93713.

In the ſame triangle S G F.

As *Radius* is in proportion
to the front of the bulwarke ——— *F G.* 280. 2, 44715.
So ſine compl. the inward flanking angle — *s. c. S G F.* 18 — 06. 9, 97821.
to the line ——— *S G* 266. 29 — 2, 42536.
whereunto addding halfe the Curtaine ——— *S I.* 210.
the ſumme is the line ——— *I G.* 476. 29.
which doubled is the diſtance of the angular
points of the bulwarkes ——— *K G.* 952. 58.

In



In the triangle IAG.

As ſine halfe the angle at the center —— s. *I AG.* 36. d. 06. —— ,23078.
to halfe the ſide of the outward pentagon —— *IG.* 476.29. —— 2,67787.
So is *Radius* in proportion to the
Semidiamet. of the outward pentagon —— *AG.* 810. 31. — 2,90865.

In the ſame triangle:

As ſine halfe the angle at the center — —— s. *I AG.* 36. d. 06. ,23078.
to ½ the ſide of the outward pentagon —— *IG* 476. 29. 2,67787.
ſo ſine compl. halfe the angle at the center — s. c. *I AG.* 36. 06. 9,90796.
to the greater perpendiculer —— —— *AI.* 655. 56. 2,81661.

In the triangle FCG.

As the ſine of the angle — —— —— s. *FCG.* 86. d. 06. ,00106.
is in proportion to the Front —— —— —— *FG.* 280. — 2,44715.
ſo ſine halfe the flanked angle —— —— s. *FGC.* 36. 06. 9,76922.
to the line —— —— —— —— *FC.* 164 98. 2,21743.

In the ſame triangle FCG.

As the ſine of the angle ——— s. *F C G.* 86. d. 06. 9,00106.
is in proportion to the front ——— *F G.* 280. —— 2,44715.
ſo is the ſine of the angle ——— s. *G F C.* 58. 00. 9,92842.
to the head-line ——— *C G.* 238. 03. 2,37663.
Which ſubſtracted from the ſemidiam. ——— *A G.* 810 31.
there remaines the ſemidiameter
of the inner pentagon ——— *A C.* 572. 28.

In the triangle FCN.

As *Radius* is in proportion
to the line before found ——— *F C.* 164. 98. 2,21743.
ſo ſine the angle forming the flanke ——— s. *F C N.* 40. d. 06. 9,80807.
to the flanke ——— *F N.* 106. 05. 2,02550.
whereto adding the line firſt found ——— *S. F.* 86. 52.
we have the diſtance of the pentag. *S N* or ——— *I D.* 192. 57.
which ſubſtracted from the perpendicular ——— *A I.* 655. 56.
leaves the perpend. of the inward pentagon ——— *I D.* 462. 99.

In the triangle FNC:

As *Radius* is in proportion
to the line before found ——— *F C.* 164. 98. 2,21743.
ſo ſine comp. the angle forming the flanke ——— s. c. *F C N.* 40. d. 06. 9,88425.
to the Gorge line ——— *N C.* 126. 38. 2,10168.
whereunto adding halfe the curtaine ——— *D N.* 210.
ſumme is the line ——— *D C.* 336. 38.
which doubled is the ſide of the inward
pentagon ——— *B C.* 672. 76.

In the triangle FPN.

As ſine the inward flanking angle ——— s. *F P N.* 18. d. 06. 0,51002.
is in proportion to the flanke ——— *F N.* 106. 05. 2,02550.
ſo ſine comp. the inward flanking angle ——— s. c. *F P N.* 18. 00. 9,97821.
to the line ——— *P N.* 326. 39. 2,51373.
which ſubſtracted from the curtaine ——— *O N.* 420.
remaines the ſecond flanke ——— *O P.* 93. 61.

In the triangle R O G.

To the line before found ——— S G. 266. 29.
adding the curtaine ——— O N. 420.
we have the line ——— R G. 606. 29

then

As the line *R O* or ——— *I D.* 192. 57. 7, 72541.
is to that line ——— *R G.* 686. 29. 2, 83651.
ſo is *Radius* in proportion
to the tangent of the angle ——— *t. R O G.* 74. d. 20'. 10, 55192.

Secondly.

As the ſine of that angle ——— *s. R O G.* 74. d. 26. 9,01646.
is in proportion to the line ——— *R G.* 686. 29. 2,83651.
ſo is *Radius* in proportion
to the longeſt line of defence ——— *O G.* 712. 80. 2,85297.

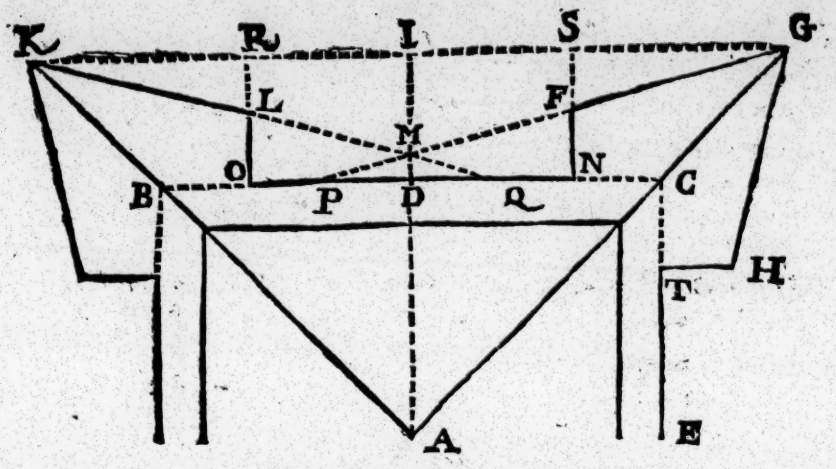
3. *Example.*

In this Tetragonall or Quadrangular Fort following
Let the length of the Curtaine be O N. 42. r. *or* 420. f.
the front of the bulworke be F G. 28. r. *or* 280. f.
the angle forming the flanke F C N. 40. d. 00.
the flanked angle of the bulworke F G H. 60. d. 00.

Then will the other angles be found by either of the rules *Chapter* 4. to be ſuch as are expreſſed in either of the two tables there: and for finding the ſides we proceed as before thus.

In the triangle S G F.

As *Radius* is in proportion
to the front of the bulworke ——— *F G.* 280. foote. 2,44715.
ſo ſine the inward flanking angle ——— *s. S G F.* 15. d. 00. 9. 41300.
to the line ——— *S F.* 72. 47. — 1,86015.



In the ſame triangle SGF.

As *Radius* is in proportion to the front of the bulwarke	*FG.* 280. foote.	2, 44715.
ſo ſine comp. the inward flanking angle	s. c. *SGF.* 15. 00.	9, 98494.
to the line	*SG.* 270. 45.	2, 43209.
whereunto adding halfe the Curtaine	*SI.* 210.	
the ſumme is the line	*IG.* 480. 45.	
which doubled is the ſide of the outward tetragon	*KG.* 960. 90.	

In the triangle IAG.

As ſine halfe the angle at the center	s. *IAG.* 45. d. 06.	0. 15051.
to halfe the ſide of the outward tetragon	*IG.* 480. 45.	2, 68165.
So is *Radius* in proportion to the ſemidiamet. of the outward tetragon	*AG.* 679. 46.	2, 83216.

In the ſame triangle.

As ſine halfe the angle at the center	s. *IAG.* 45. .06.	0, 15051.
to halfe the ſide of the outward tetragon	*IG.* 480. 45.	2, 68165.
ſo ſine compl. halfe the angle at the center	s. c. *IAG.* 45. 00.	9, 84949.
to the greater perpendiculer	*AI.* 480. 45.	2, 68165.

In

In the triangle FCG.

As the ſine of the angle ——— s. *F C G*. 95. d. 06. 0,00166.
is in proportion to the front ——— *F G*. 280. —— 2,44715.
ſo ſine halfe the flanked angle— ——— s. *F G C*. 30. d. 06. 9.69897.
to the line ——— *F* . . 140. 53. 2,14778.

In the ſame triangle FCG.

As the ſine of the angle ——— s. *F C G*. 95. 06. d. 0,00166.
is in proportion to the front ——— *F G*. 280. —— 2,44715.
ſo is the ſine of the angle ——— s. *G F C*. 55. d. 06. 9.91336.
to the head line ——— *C G*. 230. 23. 2,36217.
which taken from the greater ſemidiameter —— *A G*. 679. 46.
remaines the leſſer ſemidiameter ——— *A C*. 449. 23.

In the triangle FCN.

As *Radius* is in proportion
to the line before found ——— *F C*. 140. d. 53'. 2,14778.
ſo ſine the angle forming the flanke ——— s. *F C N*. 40. d. 00. 9.80807.
to the flanke ——— *F N*. 90. 33. 1,95585.
whereunto adding the line firſt found ——— *S F*. 72. 47.
we have the diſtance of the two tetrag. — *K G* and *B C*. 162. 80.
which ſubſtracted from the perpend. ——— *A I*. 480. 45.
there remaines the perpendiculer of
the inward tetragon ——— *A D*. 317. 65.

In the triangle FNC.

As *Radius* is in proportion
to the line before found ——— *F C*. 140. 53. 2,14778.
ſo ſine compl. the angle forming the flanke — s. c. *F C N*. 40. d. 06. 9,88425.
to the Gorge line ——— *N C*. 107. 66. 2,03203.
whereunto adding halfe the curtaine ——— *D N*. 210.
we have the line ——— *D C*. 317. 66.
which doubled is the ſide of the inward
tetragon ——— *B C*. 635. 32.

In the triaugle FPN.

As ſine the inward flanking angle ——— s. *F P N.* 15.d.06. 0,58700.
is in proportion to the flanke ——— *F N.* 90. 33 1,95585.
ſo ſine compl. the inward flanking angle — s. c. *F P N.* 15. 60. 9,98494.
to the line ——— *P N.* 337. 13. 2,52779.
which ſubſtracted from the curtaine — *O N.* 420.
remaines the ſecond flanke ——— *O P.* 82. 87.

In the triangle ROG.

To the line before found ——— *S G.* 270. 45.
adding the curtaine ——— *O N.* 420.
ſumme is the line ——— *R G.* 690. 45.

Firſt.

As the line *R O* or ——— *I D.* 162. 80. 7,78835.
is in proportion to the line ——— *R G.* 690. 45. 2,83913.
ſo is *Radius* in proportion
to the tangent of the angle ——— t. *R O G.* 76.d.44'. 10,62748.

Secondly.

As the ſine of that angle ——— s. *R O G.* 76.d. 44'. 0,01175.
is in proportion to the line ——— *R G.* 690. 45. 2,83913.
ſo is *Radius* in proportion
to the fixed or longeſt line of defence ——— *O G.* 709. 42. 2,85090.

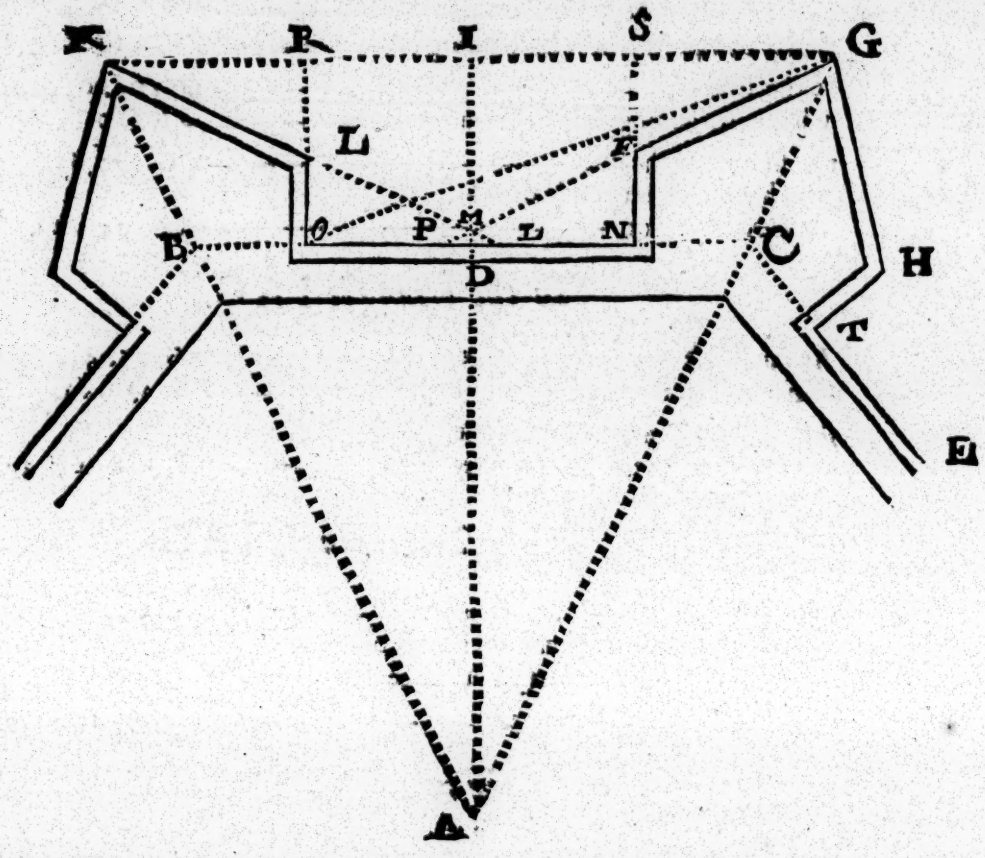
4. *Example.*

Let there be a heptagon or figure of ſeven ſides to be fortified with bulworkes, &c.

Let the length of the curtaine be O N. 420. foote
the front of the bulwarke F G. 280.
the angle of the bulwarke F G H. 85.d. 43'.

Then will the other angles be according to the ſecond

cond rule and ſecond table of the fourth Chap. and for finding the ſides we proceede as before ſaying.



In the triangle S G F.

As *Radius* is in proportion
to the front of the bulworke ——— F G. 280. —— 2,44715.
ſo ſine the inward flanking angle —— s. S G F. 21. d. 26'. 9,56279.
to the line ——— S F. 102. 31. 2,00994.

In

In the ſame triangle S G F.

As *Radius* is in proportion
to the front of the bulwerke —— *F G.* 280. — 2,44715.
ſo ſine compl. the inward flanking angle — s. c. *S G F.* 21. 26. 9,96588.
to the line —— *S G.* 260. 63. 2,41603.
whereunto adding halfe the curtaine —— *S I.* 210.
the ſumme is the line —— *I G.* 470. 63.
which doubled is the ſide of the
outward heptagon —— *K G.* 941. 26.

In the triangle I A G.

As ſine halfe the angle at the center — s. *I A G.* 25. 43. 0,36259.
to halfe the ſide of the outward heptagon — *I G.* 470. 63. 2,67268.
ſo is *Radius* in proportion to the
ſemidiameter of the outward heptagon — *A G.* 1084. 61. 3,03527.

In the ſame triangle I A G.

As ſine halfe the angle at the center — s. *I A G.* 25. d. 43′. 0,36259.
to halfe the ſide of the outward heptagon — *I G.* 470. 63′. 2,67268.
ſo ſine compl. halfe the angle at the center — s. c. *I A G.* 25 d. 43′. 9,95470.
to the greater perpendiculer — *A I.* 977. 17. 2,98997.

In the triangle F C G.

As the ſine of the angle — s. *F C G.* 75. d. 43′. 0,01364.
is in proportion to the front — *F. G.* 280. — 2,44715.
ſo ſine halfe the flanked angle — s. *F G C.* 42. 51. ½. 9,83261.
to the line — *F C.* 196. 52. 2,29340.

In the ſame triangle F C G.

As the ſine of the angle — s. *F C G.* 75. d. 43′. 0,01364.
is in proportion to the front — *F G.* 280. — 2,44715.
ſo is the ſine of the angle — s. *G F C.* 61. d. 26′. 9,94362.
to the head-line — *C G.* 253. 75. 2,40441.
which taken from the greater ſemidiameter — *A G.* 1084. 61.
there remaines the ſemid. of the inward heptagon — *A C.* 830. 86.

In

In the triangle FCN.

As *Radius* is in proportion
to the line before found ——— *F C.* 196.52. 2,29340.
so sine the angle forming the flanke ——— *s. F C N.* 40. d. 06. 9. 80809.
to the flanke ——— *F N.* 126. 32. 2,10147.
whereto adding the line first found ——— *S F.* 102 31.
summe is the distance of the heptagons ——— *I D.* 228.63.
which substracted from the perpend. ——— *A I.* 977.17.
there remaines the perpendicular
of the inward heptagon ——— *A D.* 748.55.

In the triangle FNC.

As *Radius* is in proportion
to the line before found ——— *F C.* 196. 52. 2,29340.
so sine compl. the angle forming the flanke ——— *s. c. F C N,* 40. d. 06. 9. 88495.
to the Gorge-line ——— *N C.* 150. 54. 2,18076.
whereunto adding halfe the curtaine ——— *D N.* 210.
we have the line ——— *D C.* 360. 54.
which doubled is the side of the inward
pentagon ——— *B C.* 721.08.

In the triangle FPN.

As sine the inward flanking angle ——— *s. F P N.* 21. d. 28. 0,43721.
is in proportion to the flanke ——— *F N.* 126. 32. 2,10147.
so sine compl. the inward flanking angle ——— *s. c. F P N,* 21. 26. 9. 96888.
is in proportion to the line ——— *P N.* 321. 78. 2,50756.
which substracted from the curtaine ——— *O N.* 420. 00.
remaines the second flanke ——— *O P.* 98. 22.

Lastly, *in the triangle* ROG.

To the line before found ——— *S G.* 260.63.
adding the curtaine ——— *O N.* 420.
the summe is the line ——— *R G.* 680.63.

Then Firſt.

As the line *R O* or ——— *I D.* 228. 63. 7,64087.
is in proportion to that line ——— *R G.* 680. 63. 2,83291.
ſo is *Radius* in proportion
to the tangent of the angle ——— t. *R O G.* 71. 26'. 10,47378.

Secondly.

As the ſine of that angle ——— s. *R O G.* 71. 26. 0,02321.
is in proportion to the line ——— *R G.* 680. 63. 2,83291.
ſo is *Radius* in proportion
to the fixed or longeſt line of defence ——— *R G.* 718. 00. 2,85612.

And after the forme of theſe examples, you may determine the quantities of the ſides, and lines of Forts of any other number of ſides, under or above twelve.

5. *Example.*

Laſtly, in a Quindecagon of fifteene equall ſides and angles, let theſe parts be as before, namely

The Curtaine ——— *O N.* 42. rods.
The front of the bulwarke ——— *F G.* 28. rods.
The angle forming the flanke ——— *F C N.* 40. d. 00.
And the flanked angle of the bulwarke *F G H.* 90. d. 00.

Then will the other angles be as followeth.

The angle at the center of the poligon —— *B A C.* 24. d. 00.
halfe the angle at the center is ——— *D A C.* 12. 00.
whoſe compl. is halfe the angle of the poligon *B C A.* 78. 00.

which

ons of any Regular Fortificat
d angle being halfe the angle of th

	4	5	6
	degrees.	degrees.	degree
CE.	90	108	120
GH.	60	69	75
FG.	105	109 $\frac{1}{3}$	112 $\frac{1}{3}$
GF.	15	19 $\frac{1}{3}$	22 $\frac{1}{3}$
MG.	150	141	135
N.	40	40	40

	rod.	cent	rod.	cent	rod.	ce
N.	42	00	42	00	42	0
G.	28	00	28	00	28	0
C.	10	77	12	18	13	2
C.	44	92	56	45	68	5
C.	63	53	66	36	68	5
O.	31	76	45	67	59	3
.	67	95	80	63	93	7
.	96	09	94	79	93	7
	48	04	65	23	81	1
	16	28	19	57	21	8
	9	03	10	22	11	1
	23	92	24	18	25	2
	14	95	15	90	17	31
	8	29	13	12	15	13
	0	94	71	14	71	30

A Table of the dimensions of any Regular P
the flanked angle being halfe the a

Poligons the number of their sides		4	5
		degrees.	degre
The angle of the Poligon	BCE.	90	108
The flanked angle of the bulworke	FGH.	60	69
The angle of the shoulder	NFG.	105	109
The inward flanking angle	SGF.	15	19
The outward flanking angle	KMG.	150	141
The angle forming the flanke	FCN.	40	40
		rod. cent	rod.
The Curtaine	ON.	42 00	42
The front of the bulworke	FG.	28 00	28
The Gorge-line	NC.	10 77	12
The Semidiameter of the inner Poligon	AC.	44 92	56
The side of the inner Poligon	BC.	63 53	66
The perpendicular of the inner poligon	AD.	31 76	45
The Semidiameter of the outer Poligon	AG.	67 95	80
The side of the outer Poligon	KG.	96 09	94
The perpendicular of the outter Poligon	AI.	48 04	65
The distance of the poligons	DI.	16 28	19
The flanke	FN.	9 03	10
The head-line	CG.	23 02	24
The shoulder from the Center	FC.	14 95	15
The second flanke	OP.	8 29	13
The longest line of defence	OG.	70 94	71

Place this after fol. 37.

lar Fortification from the Tetragon to the Dodecagon;
the angle of the Poligon, and 15. degrees.

5	6	7	8	9	10	11	12
egrees.	degrees.	degrees.	degrees.	degrees.	degrees.	degrees.	degrees.
108	120	128 4/7	135	140	144	147 3/11	150
69	75	79 2/7	82 1/2	85	87	88 7/11	90
109 1/2	112 1/2	114 9/14	116 1/4	117 1/2	118 1/2	119 7/22	120
19 1/2	22 1/2	24 9/14	26 1/4	27 1/2	28 1/2	29 7/22	30
141	135	130 5/7	127 1/2	125	123	121 4/11	120
40	40	40	40	40	40	40	40

od.	cent	rod.	cent	rod.	cent	rod.	cent	rod.	cent	rod.	cent	rod.	cent	rod.	cent
42	00	42	00	42	00	42	00	42	00	42	00	42	00	42	00
28	00	28	00	28	00	28	00	28	00	28	00	28	00	28	00
12	18	13	26	14	12	14	83	15	42	15	92	16	36	16	73
56	45	68	52	80	94	93	63	106	49	119	49	132	57	145	80
66	36	68	52	70	24	71	66	72	84	73	85	74	71	75	47
45	67	59	34	72	90	86	50	100	06	113	64	127	20	140	83
80	63	93	74	107	05	120	50	124	02	147	59	161	16	174	83
94	79	93	74	92	90	92	22	91	67	91	21	90	83	90	50
65	23	81	18	96	42	111	32	125	93	140	37	154	63	168	87
19	57	21	84	23	52	24	83	25	87	26	72	27	43	28	04
10	22	11	13	11	85	12	44	12	94	13	36	13	72	14	04
24	18	25	22	26	11	26	87	27	53	28	10	28	59	29	03
15	90	17	31	18	43	19	36	20	13	20	79	21	35	21	85
13	12	15	13	16	14	16	77	17	14	17	39	17	56	17	68
71	14	71	30	71	43	71	55	71	67	71	77	71	86	71	94

ion from the Tetragon to the Dodecagon;
e Poligon, and 15. degrees.

	7	8	9	10	11	12
;.	degrees.	degrees.	degrees.	degrees.	degrees.	degrees.
	128 4/7	135	140	144	147 3/11	150
	79 1/7	82 1/2	85	87	88 7/11	90
	114 9/14	116 1/4	117 1/2	118 1/2	119 7/22	120
	24 9/14	26 1/4	27 1/2	28 1/2	29 7/22	30
	130 5/7	127 1/2	125	123	121 4/11	120
	40	40	40	40	40	40

nt	rod.	cent	rod.	cent	rod.	cent	rod.	cent	rod.	cent	rod.	cent
0	42	00	42	00	42	00	42	00	42	00	42	00
0	28	00	28	00	28	00	28	00	28	00	28	00
6	14	12	14	83	15	42	15	92	16	36	16	73
2	80	94	93	63	106	49	119	49	132	57	145	80
2	70	24	71	66	72	84	73	85	74	71	75	47
4	72	90	86	50	100	06	113	64	127	20	140	83
4	107	05	120	50	124	02	147	59	161	16	174	83
4	92	90	92	22	91	67	91	21	90	83	90	50
8	96	42	111	32	125	93	140	37	154	63	168	87
4	23	52	24	83	25	87	26	72	27	43	28	04
3	11	85	12	44	12	94	13	36	13	72	14	04
2	26	11	26	87	27	53	28	10	28	59	29	03
1	18	43	19	36	20	13	20	79	21	35	21	85
1	16	14	16	77	17	14	17	39	17	56	17	68
1	71	43	71	55	71	67	71	77	71	86	71	94

which doubled is the angle of the poligon — *BCE.* 156.d.00.
And seeing the flanked ang. of the bulwork *FGH.* 90.00.
halfe the flanked angle is —— *FGC.* 45.00.
taken from halfe the angle of the poligon — *BCA.* 78.00.
leaves the inward flanking angle —— *SGF.* 33.00.
whereunto adding a right angle —— 90.00.
the summe is the angle of the shoulder — *NFG.* 123.00.
from which the c. of the an. forming the flank *NFC.* 50.00.
rests the angle opposite to the head-line — *GFC.* 73.00.
to which adding halfe the flanked angle — *FGC.* 45.00.
the summe is —— 118.00.
which substracted from two right angles —— 180.00.
remaines the angle opposite to the front —— *FCG.* 62.00.
also the c. of the inward flanking angle is — *SFG.* 57.00.
which doubled is the outward flanking ang. *KMG.* 114.00.

Having thus set downe the angles; the sides and other lines are found, as in the foure examples before going, which therefore we passe over, and will next exhibite in two tables, the lines (which we have before shewed to calculate) in a Fort of any number of sides, from the tetragon to the dodecagon, according to the angles found by either of the two rules of the fourth chapter.

In these tables we have set downe the measures of the principall lines in Forts, in rods and centesmes or hundreth parts of rods, accounting (as we have before sayd *Chap.* 1.) 10. foote to a rod, or in rods, feete and tenth parts of feete, thus 70,94 is 70 rods and 94. centesmes of a rod that is 70 $\frac{94}{100}$ rods or it is 70. rods, 9 foote and 4 tenthes of a foote, and the like is to be understood of the rest.

Many other such tables might be set downe for severall proportions used in fortification, but seeing the Arithmeticall way of calculating them by Logarithmes is so easie, it shall be sufficient to shew some of them, for which purpose we will set downe certaine questions out of *Samuel Marolois* his Fortification, and some others, wherein also you may observe the great facilitie that is in these operations by Logarithmes in comparison of those formerly used by naturall sines, tangents, and secants.

CHAP. VI.

Problemes or Questions, touching such various proportions as are or may be used in Fortification.

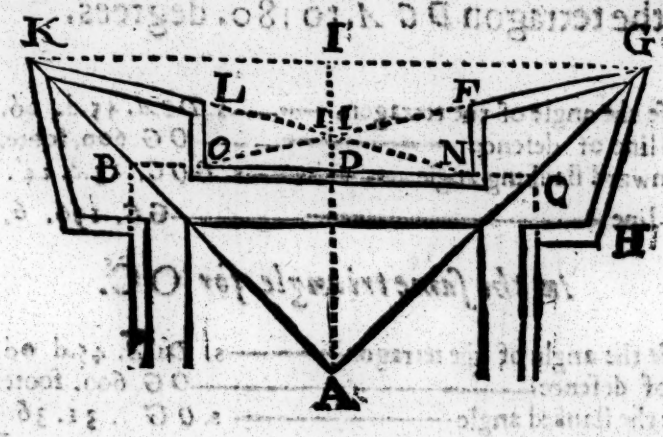
Quest. I.

SEt there be a square, the side thereof B C. *containing* 35 *parts, and let this square be fortified with bulworkes, so as the Gorge-line* N C. *may be* 7 *of those parts; the Curtaine*

O N.

O N 21. and the flanke N F. 5 parts, and let the front of the bulwarke be in a right line with the fixed line of defence, which line of defence suppose to be 60. rods, I demand the quantity of the angles, and of the parts of this Fort?

Here then in the right angled triangle *O F N.* the curtaine *O N.* being 21. parts, and the flanke *N F.* 5. parts, we may finde the angles, saying



As the flanke —— *F N.* 5. parts. 9,3010.
is in proportion to Radius
so is the Curtaine —— *O N.* 21. parts. 1,3222.
to the tangent of the angle — t. *O F N.* 76. 36. 10,6432.
whereto is equall the angle —— *I M G.* 76. 36.
which doubled is the out flanking an. K M G. 153. 12.
also the complement of O F N is — *F O N.* 13. 24.

In these tables we have set downe the measures of the principall lines in Forts, in rods and centesmes or hundreth parts of rods, accounting (as we have before sayd *Chap.* 1.) 10. foote to a rod, or in rods, feete and tenth parts of feete, thus 70|94 is 70 rods and 94. centesmes of a rod that is 70 $\frac{94}{100}$ rods or it is 70. rods, 9 foote and 4 tenthes of a foote, and the like is to be understood of the rest.

Many other such tables might be set downe for severall proportions used in fortification, but seeing the Arithmeticall way of calculating them by Logarithmes is so easie, it shall be sufficient to shew some of them, for which purpose we will set downe certaine questions out of *Samuel Marolois* his Fortification, and some others, wherein also you may observe the great facilitie that is in these operations by Logarithmes in comparison of those formerly used by naturall sines, tangents, and secants.

CHAP. VI.

Problemes or Questions, touching such various proportions as are or may be used in Fortification.

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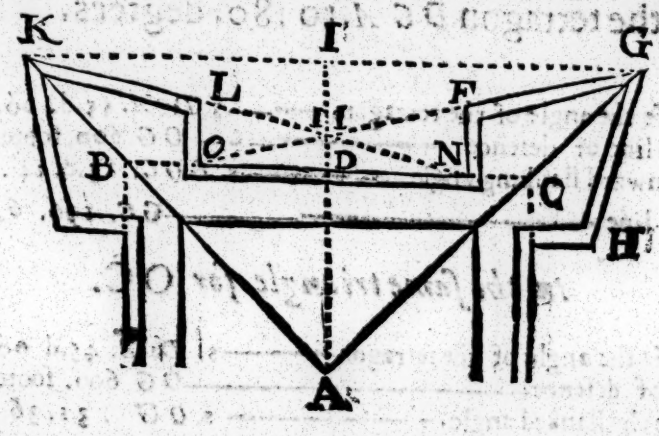
LEt there be a square, the side thereof B C. *containing* 35 *parts, and let this square be fortified with bulworkes, so as the Gorge-line* N C. *may be* 7 *of those parts; the Curtaine*

O N.

O N 21. and the flanke N F. *5 parts, and let the front of the bulworke be in a right line with the fixed line of defence, which line of defence suppose to be 60. rods, I demand the quantity of the angles, and of the parts of this Fort?*

Here then in the right angled triangle *O F N.* the curtaine *O N.* being 21. parts, and the flanke *N F.* 5. parts, we may finde the angles, saying



As the flanke —————— *F N.* 5. parts. 9,3010.
is in proportion to Radius
so is the Curtaine —————— *O N.* 21. parts. 1,3222.
to the tangent of the angle — t. *O F N.* 76. 36. ½. 10,6232.
whereto is equall the angle —— *I M G.* 76. 36.
which doubled is the out flanking an. K M G. 153. 13.
also the complement of O F N is — *F O N.* 13. 24.

also the angle ——— *IGM.* 13. 24.
which taken from halfe the angle
of the tetragon namely from ——— *IGA.* 45. 00.
there remaines half the flanked angle. *FGC.* 31. 36.
which doubled is the flanked angle — *FGH.* 63. 13.
againe to the inward flanking angle — *IGM.* 13. 24.
adding a right angle ——— 90. 00.
we have the angle of the shoulder — *NFG.* 103. 24.

Now then in the triangle *OGC.* we have the fixed line of defence *OG.* 600: foote, and the angles; for the obtuse angle *OCG.* is the complement of halfe the angle of the tetragon *DCA.* to 180. degrees.

As sine halfe the angle of the tetragon. ——— s. *DCA.* 45.d. 06. 0,1505.
to the fixed line of defence ——— *OG.* 600. foote. 2,7782.
so sine the inward flanking angle ——— s. *GOC.* 13.d. 24'. 9,3650.
to the head-line ——— *GC.* 196. 6. 2,2937.

In the same triangle for OC.

As sine halfe the angle of the tetragon ——— s. *DCA.* 45.d. 06. 0,1505.
to the line of defence ——— *OG.* 600. foote. 2,7782.
so sine halfe the flanked angle ——— s. *OGC.* 31. 36. 9,7193.
to the curtaine, and Gorge line ——— *OC.* 444. 7. 2,6480.
the fourth thereof is the Gorge ——— *NC.* 111. 2.
the residue is the curtaine ——— *ON.* 333. 5.
Also the summe of *OC* and *NG* is the
side of the inward tetragon ——— *BC.* 555. 8.
a seventh part whereof is the flanke ——— *NF.* 79. 4.

In the right angled triangle OFN *for* OF.

As the sine of the angle ——— s. *OFN.* 76.d. 36'. 0,0120.
is the proportion to the curtaine ——— *ON.* 333. 5. 2,5231.
so is *Radius* to the distance of the shoulder ——— *OF.* 342. 8. 2,5351.
which taken from the line of defence ——— *OG.* 600.
leaves the front of the bulwarke ——— *FG.* 257. 2.

In

In the triangle ADC. *for* AC.

Againe halfe the side of the tetragon is ——— *D C.* 277.9.
whereto is equall the perpendicular ——— *A D.* 277.9.

wherefore

As halfe the angle of the tetragon ——— s. *D C A.* 45.d.06. 0,1505.
is to the perpendicular ——— *A D.* 277.9. 2,4439.
so is *Radius* in proportion to the
semidiameter of the inward tetragon ——— *A C.* 393.0. 2,5944.
whereunto adding the head-line ——— *C G.* 196.6.
we have the semidiameter of the
outward tetragon ——— *A G.* 589.6.

In the triangle IGA.

As *Radius* is in proportion to the
semidiameter of the outward tetragon ——— *A G.* 589.6. 2,7706.
so sine halfe the angle of the tetragon ——— s. *I G A.* 45.06. 9,8495.
to the perpendicular ——— *A I.* 416.9. 2,6201.
from which taking the perpendic. ——— *A D.* 277.9.
rests the distance of the tetragons ——— *I D.* 139.0.
also to *A I* is equall ——— *I G.* 416.9.
which doubled is the side of the
outward tetragon ——— *K G.* 833.8.

Quest. II.

Let the Curtaine be in proportion to the Gorge-line as 3 to 1. and the Gorge-line to the flanke, as 7 to 5. and let the front of the bulworke be in a right line, with the line of defence, which line of defence suppose to be 60 rods, I demand the quantity of the angles and of the parts of the Fort?

This question is in effect the same with the former.

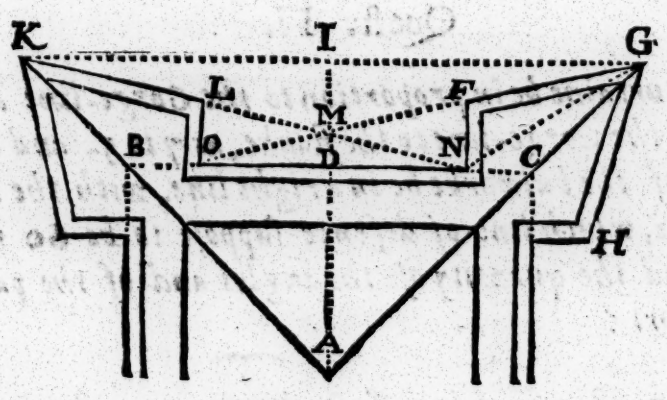
Quest.

Queſt. III.

In a quadrangular fortreſſe, let the Curtaine be foure times ſo much as the Gorge-line, and let the Gorge-line be equall to the flanke, and let the line of defence be 60. rods, and agree with the front of the bulworke, what ſhall be the angles and ſides of ſuch a Fortreſſe?

In the triangle FON.

As the Curtaine ———	*ON.* 4. parts.	9,3979.
is in proportion to *Radius.*		
So is the flanke ———	*FN.* 1. part.	0,0000.
to tang the inward flanking angle ———	t. *FON.* 14 d. 02.	9,3979.
which ſubſtracted from halfe the angle		
of the tetragon ———	*IGC.* 45. d. 00.	
leaves halfe the flanked angle ———	*FGC.* 30. 58.	
which doubled is the flanked angle ———	*FGC.* 61. 56.	
Againe the compl. of *FON* or *IGM.* is ———	*IMG.* 75. 58.	
which doubled is the outward flanking angle —	*KMG.* 151. 56.	
Laſtly to the inward flanking angle ———	*FON.* 14. 02.	
adding a right angle ———	90. 00.	
we have the angle of the ſhoulder ———	*NFG.* 104. 02.	



Then

Then for the ſides, and firſt in the triangle OGC.

As ſine halfe the angle of the tetragon ——— s. *DCA.* 45.06. 0,1505.
to the fixed line of defence ——— *OG.* 600.foote.2,7782.
ſo ſine the inward flanking angle ——— s. *GOG.* 14. 02. 9,3847.
to the head-line ——— *CG.* 205. 8. 2,3134.

In the ſame triangle OGC.

As ſine the angle *OCG* or ——— s. *DCA.* 45. 00. 0,1505.
to the line of defence ——— *OG.* 600. foote. 2,7782.
ſo ſine halfe the flanked angle ——— s. *FGC.* 30. 58. 9,7114.
to the curtaine and gorge-line ——— *OC.* 436. 6. 2,6401.
the fift part whereof is the gorge-line ——— *NC.* 87. 3.
whereto is equall the flanke ——— *NF.* 87. 3.
and ſubſtracting *NC* from *OC*
there remaines the curtaine ——— *ON.* 349. 2.

In the triangle FON.

As ſine compl. the inward flanking angle — s. c. *FON.* 14.d. 62. 0,0132.
is in proportion to the curtaine ——— *ON.* 349. 2. 2,5431.
ſo is *Radius* is proportion
to the diſtance of the ſhoulder ——— *OF.* 360. 2, 5563.
which ſubſtracted from the line of defence ——— *OG.* 600.
there remaines the front ——— *FG.* 240.
Againe if we adde halfe the curtaine ——— *DN.* 174. 6.
to the gorge-line ——— *NC.* 87. 3.
the ſumme is the line ——— *DC.* 261. 9.
whereto is equall the perpendicular ——— *AD.* 261. 9.
and the ſide *DC* doubled is the ſide
of the inward tetragon ——— *BC.* 523. 8.

In the triangle ADC.

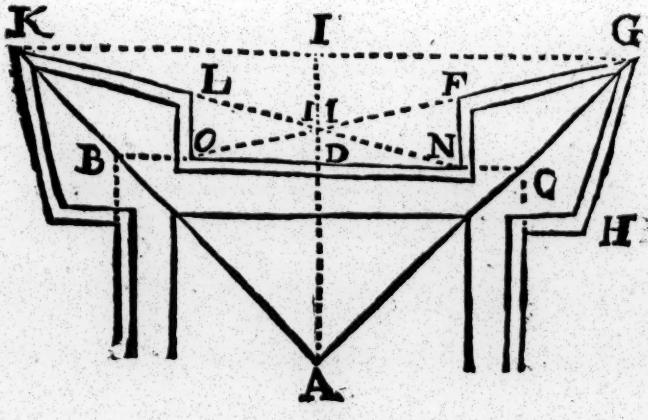
As ſine halfe the angle of the tetragon ——— s. *DCA.* 45.d. 06. 0,1505.
to the perpendicular ——— *AD.* 261. 9. 2,4182.
ſo is *Radius* in proportion to the
ſemidiameter of the inward tetragon ——— *AC.* 370. 4. 2,5687.
whereunto adding the head-line ——— *CG.* 205. 8.
we have the ſemidiameter of the outward tetragon — *AG.* 576. 2.

In the triangle I A G.

As *Radius* is in proportion to the
semidiameter of the outward tetragon —— *A G.* 576. 2. 2,7606
so sine halfe the angle of the tetragon —— *I G A.* 45.00. 9,8495
to the perpendiculer —— *A I.* 407. 4. 2,6101.
from which substracting —— *A D.* 261. 9.
remaines the distance of the tetragons —— *D I.* 145. 5.
Lastly *A I* being here equall to —— *I G.* 407. 4.
which doubled is the side of the outward tetragon — *K G.* 814. 9.

Quest. IIII.

Let there be a Quadrangular Fort whose longest line of defence O G *admit to be* 600 *foote, the flanked angle* F G H 60 *degrees and the angle* F G N *a fourth part of the flanked angle namely* 15 *degrees, what are the other dimensions of such a Fort?*



Here then halfe the flanked angle —— *F G C.* 30. d. 06.
taken from halfe the angle of the tetragon —— *I G A.* 45. 00.
leaves the inward flanking angle —— *I G M.* 15. 00.
whereto is equall —— *F O N.* 15. 00.
the compl: of either is —— *I M G.* 75. 00.

which

which doubled is the outward flanking angle— K M G. 150. 00.
and if to the angle F O N we adde ——— 90. 00.
we have the angle of the ſhoulder ——— N F G. 105. 00.
laſtly ſubſtracting the angle ——— N G C. 15 00.
from halfe the angle of the tetragon ——— D C A 45. 00.
there remaines the angle ——— G N C. 30. 00.

In the triangle O G C.

As ſine halfe the angle of the tetragon ——— s. D C A. 45. d. 06. 0,1505.
to the fixed line of defence ——— O G. 600. foote 2,7782.
ſo is ſine the inward flanking angle ——— s G O C. 15. 00. 9,4130.
to the head-line ——— C G. 219. 6. 2,34 17.

In the ſame triangle.

As ſine halfe the angle of the tetragon ——— s. D C A. 45. d. 06. 0,1505.
is to the fixed line of defence ——— O G. 600. foote. 2,7782.
ſo is ſine halfe the flanked angle ——— s. O G C. 30. 00. 9,6990.
to the curtaine and one gorge-line ——— O C. 424. 3. 2,6277.

In the triangle G N C.

As the ſine of the angle ——— s. G N C. 30. d. 06. 0,3010.
is to the head line ——— G C. 219. 6. 2,3417.
ſo is the ſine of the angle ——— s. N G C. 15. 06. 9,4130.
to the gorge-line ——— N C. 113. 7. 2,0557.
which ſubſtracted from the line ——— O C. 424. 3.
there remaines the curtaine ——— O N. 310. 6.

In the triangle F O N:

As Radius is in proportion
to the curtaine ——— O N. 310. 6. 2,4922.
ſo tang. the inward flanking angle ——— t. F O N. 15. 00. 9,4280.
to the flanke ——— F N. 83. 2. 1,9202.

In the ſame triangle:

As ſine the inward flanking angle —— s. FON. 15.d. 06. 0,5870.
is in proportion to the flanke —— FN. 83,2. 1,9202.
ſo is *Radius* in proportion
to the diſtance of the ſhoulder —— OF. 321.5. 2,5072.
which taken from the line of defence —— OG. 600.
leaves the front of the bulwarke —— FG. 278.5.

In the triangle ADC.

And if unto halfe the curtaine —— DN. 155. 3.
we adde the gorge-line —— NC. 113.7.
the ſumme is the line —— DC. 269.0.
whereto is equall the perpendicular —— AD. 269.0.
Alſo the line D C doubled is the ſide
of the inward tetragon —— BC. 538.0.

As ſine halfe the angle of the tetragon —— s. DCA. 45.d. 06. 0,1505.
to the perpendiculer —— AD. 269.0. 2,4300.
ſo is *Radius* in proportion to the
ſemidiameter of the inward tetragon —— AC. 380.4. 2,5805.
whereunto adding the head-line —— CG. 219.6.
we have the ſemidiameter of the
outward tetragon —— AG. 600.0.

In the triangle IGA.

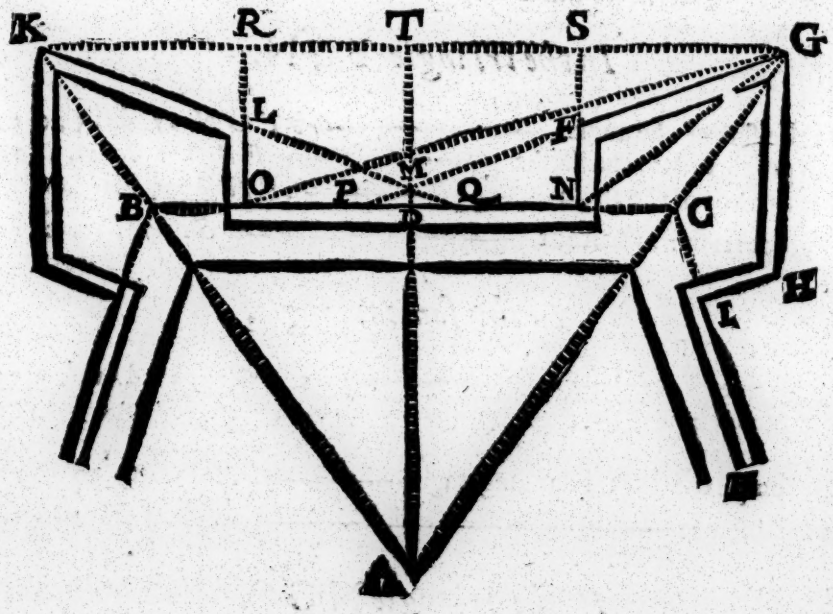
As *Radius* is in proportion to the
ſemidiameter of the outward tetragon —— AG. 600. 2,77811.
ſo ſine halfe the angle of the tetragon —— s. IGA. 45.d. 06. 9 8495.
to the perpendiculer —— AI. 424.3. 2,6276.
from which ſubſtracting the perpend. —— AD. 269.0.
reſts the diſtance of the tetragons —— ID. 155.3.
Laſtly, *IG.* (which is equall to *AI*) doubled is
the ſide of the outward tetragon —— KG. 848.5.

We ſet downe the meaſures of the parts in feete, and tenth parts of feete, that being alwayes or for the moſt

moſt part ſufficient, but when you deſire more exactneſſe, you may uſe the logarithmes, to the eight places, or unto ſixe places as in this next queſtion wee have done.

Queſt. V.

In this figure of a Pentagonall Fort, let the flanked angle bc *69. degrees, and let the angle* FGN *be a fourth part thereof, namely* 17. d. 15'. *and the flanke* FN. 10. *rods and* 8 *foote; and the Curtaine* ON 36. *rods; I demand the quantity of each part of ſuch a Fort?*



From halfe the angle of the pentagon ——— I G A. 54. d. 00.
ſubſtract halfe the flanked angle ——— F G C. 34. 30.
reſts the inward flanking angle I G P or ——— F P N. 19. 30.
which added to a right angle ——— 90.
makes the angle of the ſhoulder ——— N F G. 109. 30.
And if from halfe the angle of the
pentagon we ſubſtract the angle ——— N G C. 17. d. 15'.
there remaines the angle ——— G N C. 36. 45.
whoſe complement is ——— F N G. 53. 15.

Firſt then in the triangle FPN.

As ſine the inward flanking angle ——— s. F P N. 19. d. 30'. 0,47650.
is in proportion to the flanke ——— F N. 108. foote. 2,03342.
ſo ſine compl. the ſame angle ——— s. c. F P N. 19. 30. 9,97435.
to the part of the curtaine ——— P N. 304. 98. 2,48427.
which ſubſtracted from the curtaine ——— O N 360.
there remaines the ſecond flanke ——— O P. 55. 2.

In the triangle FGN.

As the ſine of the angle ——— s. F G N. 17. d. 15'. 0,52791.
is in proportion to the flanke ——— F N. 108. foote. 2,03342.
ſo is the ſine of the angle ——— s. F N G. 53. d. 15'. 9,90377.
in proportion to the front ——— F G. 291. 81. 2,46510.

In the ſame triangle.

As the ſine of the angle ——— s. F G N. 17. d. 15'. 0,52791.
is in proportion to the flanke ——— F N. 108. foote. 2,03342.
ſo ſine the angle of the ſhoulder that is
ſine compl. the inward flanking angle ——— s. c. F P N. 19. 30 9,97435.
to the diſtance ——— N G. 343. 30. 2,53568.

In the triangle NGC.

As ſine halfe the angle of the pentagon ——— s. D C A. 54. d. 00. 0,09204.
to the diſtance before found ——— N G. 343. 30. 2,53568.
ſo ſine $\frac{1}{4}$ of the flanked angle ——— s. N G C. 17. 15. 9,47209.
to the gorge-line ——— N C. 125. 84. 2,09981.

In

In the ſame triangle.

As ſine halfe the angle of the pentagon —— s. D C A. 54.d. 06. 0,09204.
is in proportion to the ſayd diſtance —— N G. 343.30.2, 53568.
ſo the ſine of the angle —— s. G N C. 36. 45. 9, 77694.
to the head-line —— C G. 253.90. 2,40466.

In the triangle OGN.

As the ſumme of O N and N G —— 703. 30. 7,15286.
is to the difference of O N and N G —— 16,70. 1,22272.
ſo tang. halfe the angle G N C —— t. 18.d. 22'. ½. 9,52136.
to the tangent of the difference —— 00.27 ⅛. 7,89694.
which added makes the angle —— O G N. 18. d. 49. ⅝.

Secondly.

As the ſine of that angle —— s. O G N. 18. d. 49' ⅝. 0,49118.
is in proportion to the curtaine —— O N. 360. —— 2,55630.
ſo the ſine of the angle —— s. G N C. 36. d. 45'. 9,77694.
to the longeſt line of defence —— O G. 667.46. 2,82442.

In the triangle A D C.

Halfe the curtaine is —— D N. 180 foote.
and the gorge-line is —— N C. 125. 84.
the ſumme of theſe —— D C. 305. 84.
which doubled is the ſide of the inward pentagon — B C. 611.67.
As tang. halfe the angle at the center —— t. D A C. 36. d. 06. 0,13873.
to halfe the ſide of the inward pentagon —— D C. 305. 84. 2,48549.
ſo is *Radius* in proportion to the
the leſſer perpendiculer —— A D. 420.94. 2,62422.

In the ſame triangle.

As ſine halfe the angle at the center —— s. D A C. 36. d. 06. 0, 23078.
to halfe the ſide of the inward pentagon —— D C. 305. 84. 2,48549.
ſo is *Radius* in proportion to the
ſemidiameter of the inward pentagon —— A C. 520.32. 2,71627.
whereto adding the head-line —— C G. 253.90.
we have the ſemid. of the outward pentag. —— A G. 774.22.

In

In the triangle I G A.

As *Radius* is in proportion to the
semidiamet. of the outward pentagon —— *A G.* 774. 22. 2,88886.
so sine halfe the angle at the center —— *s. I A G.* 36. d. 06. 9,76922.
to the line —— *I G.* 455. 08. 2,65808.
which doubled is the side of the outward
pentagon —— *K G.* 910. 16.

In the same triangle.

As *Radius* is in proportion to the
semidiamet. of the outward pentagon —— *A G.* 774. 22. 2, 88886.
so sine halfe the angle of the pentagon —— *s. I G A.* 54. d. 06. 9, 90796.
to the perpendiculer —— *A I.* 626. 36. 2,79682.
from which substracting the perpend —— *A D.* 420. 94.
there remaines the distance of the pentagons —— *D I.* 205. 42.

Queſt. VI.

In the hexagonall Fort following; Let the front of the bulwarke be in proportion to the Curtaine as 2 *to* 3. *and to the flanke, as* 5 *to* 2. *and let the distance of the diamond points of the bulworkes* K G. *be* 84. *rods, and the flanked angle of the bulworke,* 75. d. *I would know the fronts, curtaines and other lines of such a Fort?*

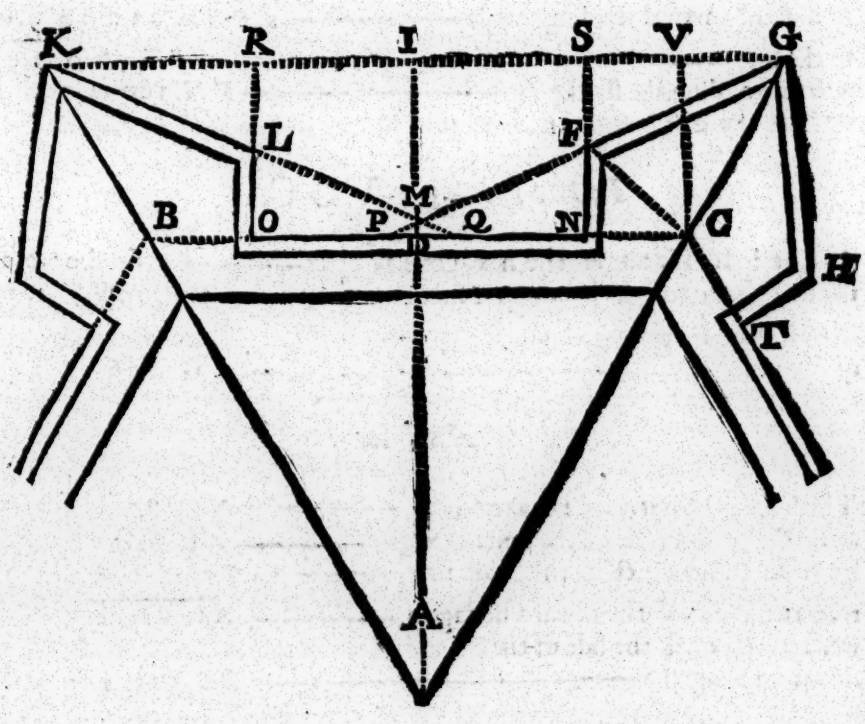
From halfe the angle of the hexagon —— *s G C.* 60. d. 06.
take halfe the flanked angle —— *F G C.* 37. 30.
rests the inward flanking angle —— *s G F.* 22. 30.
whose complement is —— *s F G.* 67. 30.

First

First then in the triangle SFG.

As *Radius* is in proportion
to the front of the bulworke ——— F.G. 2. parts. 0, 3010.
ſo the ſine of the angle ——— s. ∠ F G. 67. d. 30. 9, 9656.
to the line ——— SG. 1.8478. 0,2666.
whereunto adding halfe the curtaine ——— D N. 1. 5000.
we have the line ——— I G. 3. 3478.

Which being halfe the diſtance of the diamond points of the Bulworkes *K G.* is by ſuppoſition *I G.* 42. roddes or 420. feete.



As the line *I G.* in parts —— *I G.* 3.3478. co.ar. 9,47524.
is to the front *F G.* in parts —— *F G.* 2 parts. — 0,30103.
ſo is the ſame line *I G.* in feete —— *I G.* 420 feete. — 2,62325.
to the ſayd front *F G.* in feete. —— *F G.* 250.9. — 2,39952.

As the front in parts —— *F G* 2. 9,6990.
is to the curtaine in parts —— *O N.* 3. 0,4771.
ſo is the front in feete —— *F G.* 250.9. 2,3995.
to the curtaine in feete —— *O N.* 376.4. 2,5756.

As the front in parts —— *F G.* 5. 9,3010.
is to the flanke in parts —— *F N.* 2. 0,3010.
ſo is the front in feete —— *F G.* 250.9. 2,3995.
to the flanke in feete —— *F N.* 100.4. 2,0015.

In the triangle S G F.

As *Radius* is in proportion
to the front of the bulworke —— *F G.* 250.9 2,3995.
ſo ſine the inward flanking angle —— *s. S G F.* 22.d. 30 9,5828.
to the line —— *S F.* 96.0. 1,9823.
whereto adding the flanke —— *F N.* 100.4.
we have the diſtance of the hexagons *N S.* or —— *C V.* 196.4.

In the triangle V G C.

As ſine halfe the angle the hexagons *N S.* or —— *C V.* 60.d.00.0,0625.
to the diſtance of the hexagons *N S* or —— *V C.* 196.4. 2,2931.
ſo is *Radius* in proportion
to the head-line —— *C G.* 226.8. 2,3556.

And as

The ſide of the outward hexagon is —— *K G* 840.
ſo is the ſemidiamet. of the ſame hexagon —— *A G.* 840.
from which ſubſtracting the head-line —— *C G.* 226.8.
reſts the ſemid. of the inward hexagon. —— *A C.* 613.2.
whereto is equall the ſide of the
inward hexagon —— *B C.* 613.2.
the halfe whereof is —— *D C.* 306.6.
from which ſubſtracting halfe the curtaine —— *D N.* 188.2.
there remaines the Gorge-line —— *N C.* 118.4.

In the triangle ADC.

As *Radius* is in proportion to the
semidiameter of the inward hexagon ——— *A C.* 613. 2. 2,7876.
so sine halfe the angle of the hexagon ——— *s. D C A.* 60. d. 00. 9,9375.
to the perpendicular ——— *A D.* 531. 1. 2,7251.
&c. as before.

Quēst. VII.

Let there be a hexangular Fort, and let the distance of the diamond points of the bulwarkes be 86 *rods* 4. *foote, the Curtaine* 38 *rods* 4 *foote, the flanke* 10 *rods, and the flanked angle of the bulwarke* 75. d. 00. *what shall bee the fronts, the longest and shortest lines of defence, the gorges and other parts of this fort?*

Quest. VIII.

In a hexangular fort, let the Gorge-line be in Proportion to the flanke, as 10. *to* 7. *and to the side of the inward hexagon as* 2. *to* 9. *and let the second flanke be in proprotion to the first, as* 6. *to* 7. *and the longest line of defence* 72. *rods: what shall be the other parts of such a Fort?*

Quest. IX.

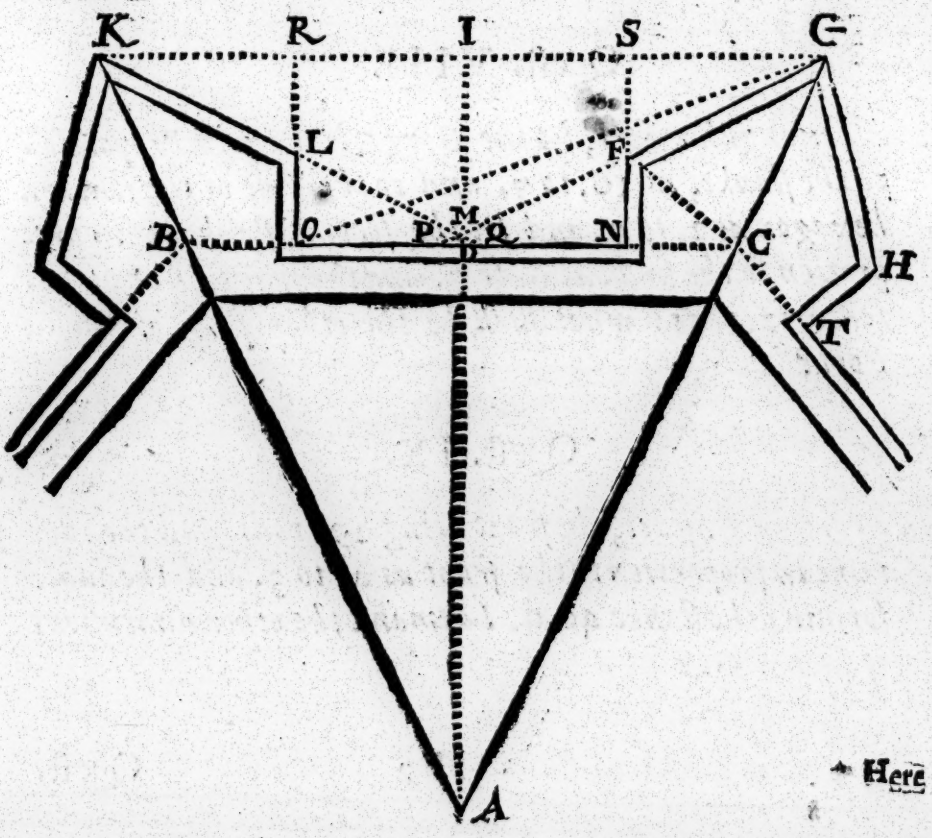
In a fort of 6. *sides, the front being* 29. *rods, and the curtaine in proportion to the front as* 4. *to* 3. *and the angle forming the flanke* 40. d. *I demand the other dimensions of such a fort?*

Queſt. X.

In a fort of ſixe ſides, admit the flanked angle of the bulworke to be 80. d. *and the front in proportion to the curtaine as* 2. *to* 3. *and let the front be* 29. *rods, and the angle forming the flanke* 40. *degrees: what are the dimenſions of the other parts of ſuch a Fort?*

Queſt. XI.

There is a regular fort of 7. *bulworkes whoſe flanke is* 12. *rods, and the diſtance of the angular points of its bulworkes is* 86. *rods* 4. *foote, and the flanked angle of the bulworke.* 80. d. *I would know the other dimenſions of this heptagon ſuppoſing the ſecond flanke to be* 12. *rods?*



Here

Here according to the third chapter I finde
the angle at the center of the heptagon —— B A C. 51. d. 26. fere.
the halfe thereof —— A. D. A. C. 25. 43.
whose complem. is halfe the angle of the heptagon —— D. C. A. 64. 17.
from which substracting halfe the flanked angle —— F G C. 40. 00.
there remaines the inward flanking angle —— I G F. 24. 17.
whereto is equall the angle —— G P C. 24. 17.
the complement of either is P F N or —— S F G. 65. 43.
which doubled is the outward flanking angle —— K M G. 131. 26.
Also the compl. of S F G. to 180. d. is the angle of
the shoulder —— N F G. 114. 17.

Then for the sides, and first in the triangle F P N.

As sine the inward flanking angle —— s. F P N. 24. d. 17'. 0,3858.
is in proportion to the flanke —— F N. 120. foote. 2,0792.
so is the sine of the angle —— s. P F N. 65. d. 43'. 9,9598.
to the intersection of the curtaine —— P N. 266. 0. 2,4248.
whereto adding the second flanke —— O P. 120.
we have the curtaine —— O N. 386. foote. fere.

In the same triangle.

As sine the inward flanking angle —— s. F P N. 24. d. 17'. 0,3859.
is in proportion to the flanke —— F N. 120. foote. 2,0792.
so is *Radius* in proportion
to the line —— P F. 291. 8. 2,4651.

In the triangle S G F.

From the side of the outward heptagon —— K G. 864.
substracting the curtaine R S or —— O N. 386.
there remaines the summe of K R and —— S G. 478.
the halfe whereof is the line —— S G. 239.

As the sine of the angle —— s. S F G. 65. d. 43'. 0,0402.
is in proportion to the line —— S G. 239. foote. 2,3784.
so sine the inward flanking angle —— s. S G F. 24. 17. 9,6141.
to the line —— S F. 107. 8. 2,0327.
which added to the flanke —— N F. 120.
gives the distance of the heptagons —— N S. 227. 8.

In the ſame triangle.

As the ſine of the angle ——— s. *S F G.* 65. d. 43'. 0,0402.
is in proportion to the line ——— *S G.* 239. 2,3784.
ſo is *Radius* in proportion
to the front of the bulworke ——— *F G.* 262. 2. 2,4186.
whereto adding the line before found ——— *P F.* 291. 8.
we have the ſhorteſt line of defence ——— *P G.* 554. 0.

In the triangle G P C.

As ſine halfe the angle of the heptagon ——— s. *D C A.* 64. d. 17'. 0,0453.
is in proportion to the line ——— *P G.* 554. 2,7435.
ſo ſine the inward flanking angle ——— s. *G P C.* 24. 17. 9,6141.
to the head-line ——— *C G.* 252. 9. 2,4030.

In the ſame triangle.

As ſine halfe the angle of the heptagon ——— s. *D C A.* 64. d. 17'. 0,0453.
to the ſhorteſt line of defence ——— *P G.* 554. 2,7435.
ſo is the ſine of halfe the flanked angle ——— s. *P G C.* 40 d. 06. 9,8081.
to the line ——— *P C.* 395. 3. 2,5969.
from which ſubſtracting the line ——— *P N.* 266.
there remaines the gorge-line ——— *N C.* 129. 3.

In the triangle I A G.

As ſine halfe the angle at the center ——— s. *I A G.* 25. d. 43'. 0,3616.
to halfe the ſide of the outward heptagon ——— *I G.* 432. 2,6355.
ſo is *Radius* in proportion to the
ſemidiamet. of the outward heptagon ——— *A G.* 995. 6. 2,9981.
from which ſubſtracting the head-line ——— *C G.* 252 9.
leaves the ſemid. of the inward heptagon ——— *A C.* 742. 7.

If further you deſire the fixed line of defence *O G.* you have the right angle triangle, *O R G.* the baſe *R G.* 625. feete, and the perpendiculer *O R.* 227. 8. whereby *O G.* is eaſily found by the firſt caſe of plaine triangles.

Queſt.

Quēſt. XII.

There is a regular Fort of 7. ſides, whoſe flanke is a 11. *rods, the diſtance of the angular points of the bulworkes,* 87. *rods, the flanked angle of the bulworke* 80. d. *I would know the other parts of this fort, ſuppoſing the ſecond flanke to be* 9. *rods?*

Queſt. XIII.

There is a heptangular Fort, whoſe Gorge-line is 14. *rods, the flanke* 12. *rods, and the curtaine* 38. *rods: I demand the quantity of the other parts of ſuch a ſeptangular fort, the flanked angle of its bulworke being* 79 $\frac{3}{7}$. *degrees?*

Queſt. XIIII.

There is a regular Fort of 7. *bulworkes the flanked angle of each bulworke being* 86. deg. *and the front being* 29. *rods, is in proportion to the Curtaine as* 2. *to* 3. *the angle forming the flanke,* FCN. *admit to be* 40. *degrees: I would know the dimenſions of the other parts of ſuch a Fort?*

Queſt. XV.

In a fort of eight angles, let the flanke be 14. *rods, the front* 29. *rods, the curtaine* 43. *rods, the flanked angle of the bulworke* 90. *deg. what are the other parts of ſuch a fort?*

Queſt.

Queſt. XVI.

In a fort of eight ſides, let the flanke be 13. rods, the ſecond flanke 12. rods, the diſtance of the angular points of the bulworkes 92. rods, the flanked angle 82. deg. 30. what ſhall be the curtaines, fronts, gorges, and other parts of ſuch a fort?

Queſt. XVII.

Let the flanked angle of the bulworke be 90. deg. the angle forming the flanke FCN. *40. deg. and let the front be in proportion to the curtaine as 2. to 3. ſuppoſing then the front to be 24. rods; what ſhall be the other parts of ſuch a fort of 8. ſides.*

Queſt. XVIII.

Let there be a fort of 9. bulworkes, whoſe curtaine let be 39 rods, the front of each bulworke 26, the flanke 13 rods: what ſhall be the other parts of ſuch a fortreſſe, ſuppoſing the flanked angle of each bulworke to be 85. degrees?

Queſt. XIX.

In a fort of 9 ſides, let the flanked angle be 85. deg. the ſhorteſt line of defence 60. rods, the longeſt line of defence 72. rods. I demand the quantities of the other parts of ſuch a fort, ſuppoſing the Gorge-line to be in proportion to the flanke as 4. to 3?

Queſt.

Queſt. XX.

There is a fort of nine ſides, whoſe flanked angle is 85. *deg. the ſhorteſt line of defence ſcowring the front* 60. *rods, and the longeſt line of defence drawne from the flanke* 72. *rods, the perpendicular from the angular point of the bulworke to the flanke extended* S G. *is equall to the diſtance of the outward and inward Nonagons* SN. *and either of them in proportion to the ſide of the outward nonagon, as* 2 *to* 7. *what ſhall be the other parts of ſuch a fort?*

Queſt. XXI.

Admit that of a regular fort having ten ſides, the flanked angle be 87 deg. *the Gorge-line in proportion to the flanke, as* 4. *to* 3. *and the lines of defence, namely the ſhorteſt* 60. *rods, and the longeſt* 72. *rods: what will be the other parts of ſuch a fort?*

Queſt. XXII.

Againe admit in ſuch a fort the flanked angle be 87. deg. *the fixed line of defence* 72. *rods, the flanke* 13 $\frac{1}{2}$. *rods, and the gorge-line* 18. *rods; there is required the other parts of ſuch a fort?*

Queſt. XXIII.

In a fort of a eleven ſides, let the front be in proportion to the curtaine, as 2. *to* 3. *and the gorge-line to the flanke, as* 4 *to* 3. *and let the diſtance of the angular points of the bulworkes be* 90. *rods, and the flanked angle of the*

bulworke 88 $\frac{7}{11}$ deg. *I would know the other parts of such a fort?*

Queſt. XXIIII.

In such a Fort, let the front be in proportion to the curtaine as 2 *to* 3. *and the gorge-line to the flanke, as* 8. *to* 5. *and let the fixed line of defence be* 72. *rods: what shall be the other parts of such a Fort, the angle of the bulworke being* 88 $\frac{7}{11}$. *degrees?*

Queſt. XXV.

In a fort of 12. *sides let the flanke be* 14. *rodds, the front* 28. *rods, and the curtaine* 42. *rods, and the flanked angle of the bulworke* 90. deg. *and let the other parts of such a fort be required?*

Queſt. XXVI.

In a fort of 12. *sides, let the shorteſt line of defence scowring the front be* 54. *rods and the longeſt line of defence* 72. *rods, and let the gorge-line be in proportion to the flanke, as* 4. *to* 3. *and the flanked angle of the bulworke* 90. deg. *what shall be the other parts of such a fort?*

Queſt. XXVII.

In such a fort let the flanked angle be a right angle, and the angle forming the flanke 38. deg. *the front of the bulworke* 28. *rods, and the longeſt line of defence,* 72. *rods; what shall be the dimensions of the other parts of such a fort?*

Sundry

Sundry other ſuch queſtions or problemes are and may be framed, according to the ſeverall proportions uſed by ſeverall nations and by ſundry men.

As *Speckelius* aſſuming the ſide of the inward poligon to be 100. rods, would have the Curtaine to be 50. and the front 40. and the flanke 15. rods.

The *Italians* (according to the ſame *Speckelius*) make the ſide of the poligon to be fortified 80. rods.

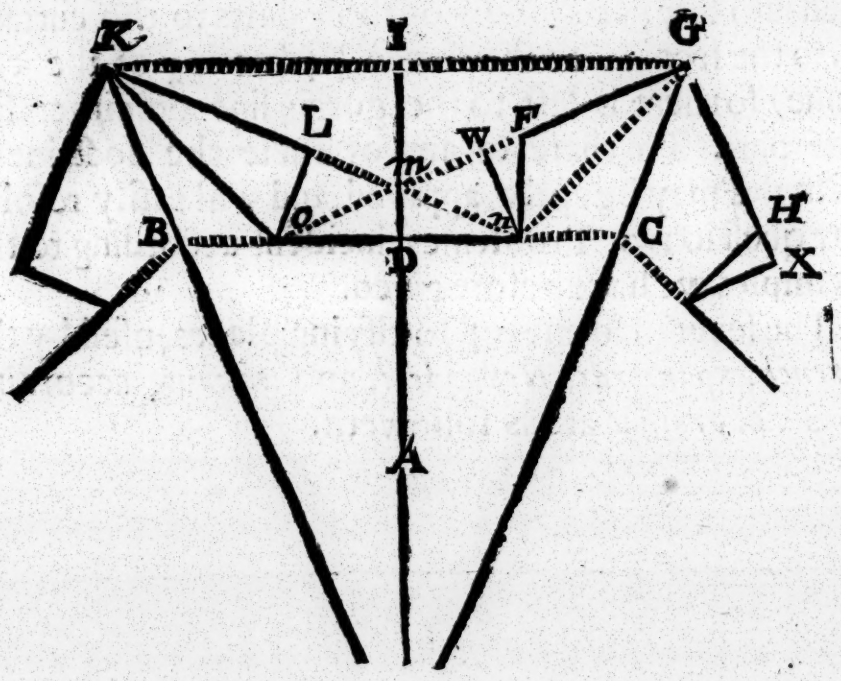
Some in the largeſt Fort would have the front 40. rods in a meane fort 35. and in the leaſt 30. rodds. And the curtaine in proportion to the front, as 5 to 4. and the flanke in proportion to the front as 2. to 5.

Others dividing the ſide of the poligon to be fortified into five parts, allow of thoſe parts to the curtaine 3. to the front 2. to the flanke $\frac{1}{4}$ (that is $\frac{1}{4}$ of the curtaine) ſo there is left to the gorge-line on either ſide one part. To theſe or any of theſe the doctrine of triangles may be aptly applyed, and will eaſily reſolve any queſtions or Problemes incident according to the examples we have before given.

The ſeverall formes of fortifying places, uſed by the *French*, *Spaniards*, *Hollanders*, and *Italians*, according to S^r. *de Praiſſac* are as followeth.

THE FRENCH FORTIFICATION.

AS in this figure, let *A G.* and *A K.* be the ſemidiameters of the outward poligon, and *K G.* the ſide thereof which is alſo the diſtance of the anguler points of the bulworks, then making the angle *O G A.* and *N K A* (or which are the ſame *O G C.* and *N K B.*) either of them 45. deg. the whole flanked angle of the bulworke



F G H will be 90. deg. that is a right angle: And againe ſubdividing the angles, *F G C.* and *L K B.* into two equall parts by the line *G N* and *K O* draw by the interſections

fections, at *O.* and *N.* the curtaine *O N.* and ſo *O G.* and *N K.* are the lines of defence, To which lines of defence, letting fall from the points *O.* and *N.* the perpendiculars *O L.* and *N W.* they are the flankes; and *L K.* and *W G.* the fronts of the bulworkes, in ſuch fortsas have not more than eight ſides; but in forts that have more than eight ſides, the flankes are perpendiculer to the curtaines, as *N F.* and then the front is *F G.*

Here then according to this deſigne, knowing the number of the ſides of the poligon, we may finde all the angles, according to the method and example following, as ſuppoſe this to be an Octagon.

From halfe the angle of the poligon —— I G C. 67. d. 30.
ſubſtracting halfe the flanked angle —— M G C. 45.
there reſts the inward flanking angle —— I G M. 22. 30.
whoſe complement is the angle —— I M G. 67. 30.
which doubled is the outward flanking an. K M G. 135. 00.
alſo ſubſtracting the angle 22. d. 30. —— N G C. 22. 30.
from halfe the angle of the poligon —— D C A. 67. 30.
there remaines the angle —— G N C. 45. 00.
whoſe complement is the angle —— F N G. 45. 00.
alſo the compl. of W G N. 22. d. 30. *is* —— W N G. 67. 30.
and the comp. of N O W. 22. d. 30. *is* —— W N O. 67. 30.

Now if there be further the quantity of ſome one of the ſides or lines determined, we may finde the reſt.

As if there were given the curtaine *O N.* wee may in the right angled triangle *N O W.* finde the flanke *N W.* and in the right angled triangle *N W G.* the front *W G.*

So if there were given the front, *W G.* wee might thence find the flank *W N.* and thence the curtaine *O N.* then the line of defence *O G.* and so the rest.

As suppose in this fort of 8. sides we determine the line of defence to be 72. roddes or 720. foote.

Then first in the triangle O G N.

As the sine of the angle *O N G.* or	s. *G N C.* 45. 06.	0,1505.
to the line of defence	*O G.* 720. foote.	2, 8574.
so sine a fourth of the flanked angle	s. *O G N.* 22. d. 30.	9, 5828.
to the curtaine	*O N.* 389. 7.	2, 5907.

In the triangle O G C.

As sine halfe the angle of the poligon	s. *D C A.* 67. d. 30.	0,0344.
to the line of defence	*O G.* 720.	2,8573.
so sine halfe the flanked angle	s. *O G C.* 45. 06.	9,8495.
to the line	*O C.* 551. 1.	2, 7412.
from which substracting the curtaine	*O N.* 389. 7.	
there remaines the Gorge-line	*N C.* 161. 4.	
which added to halfe the curtaine	*D N.* 194. 8.	
the summe is the line	*D C.* 356. 2.	
which doubled is the side of the inward poligon	*B C.* 712. 4.	

In the same triangle:

As sine halfe the angle of the poligon	s. *D C A.* 67. d. 30.	0,0344.
to the line of defence	*O G.* 720.	2,8573.
so sine the inward flanking angle	s. *G O C.* 22. 30.	95828.
to the head-line	*C G.* 298. 2.	2,4745.

In the triangle N O W.

As *Radius* is in proportion to the curtaine	*O N.* 389. 7.	2,5907.
so sine the inward flanking angle	s. *N O W.* 22. 30.	9,5828.
to the flanke	*N W.* 149. 1.	2,1735.

In

In the ſame triangle.

As *Radius* is in proportion
to the Curtaine —— *O N.* 389.7.2,5907.
ſo ſine compl. the inward flanking angle —— s.c. *NON.* 22.30.9,9656.
to the diſtance of the ſhoulder —— *O W.* 360.0.2,5563.
which taken from the line of defence —— *O G.* 720.0.
leaves the front of the bulworke —— *W G.* 360.0.

The front is here one halfe of the line of defence, becauſe the triangles *O N W.* and *G N W.* are equall and Equiangle.

If further you deſire the ſide of the outward poligon *K G.* we have in the triangle *K O G.* the ſide *O G.* being the line of defence, and the angles whereby we may finde *K G.* the halfe whereof is *I G.* ſo that in the right angled triangle *G I A.* we have the angles and one of the ſides *I G.* whereby we may finde the perpendicular of the outward poligon, *A I.* and the ſemidiameter of the ſame *A G.*

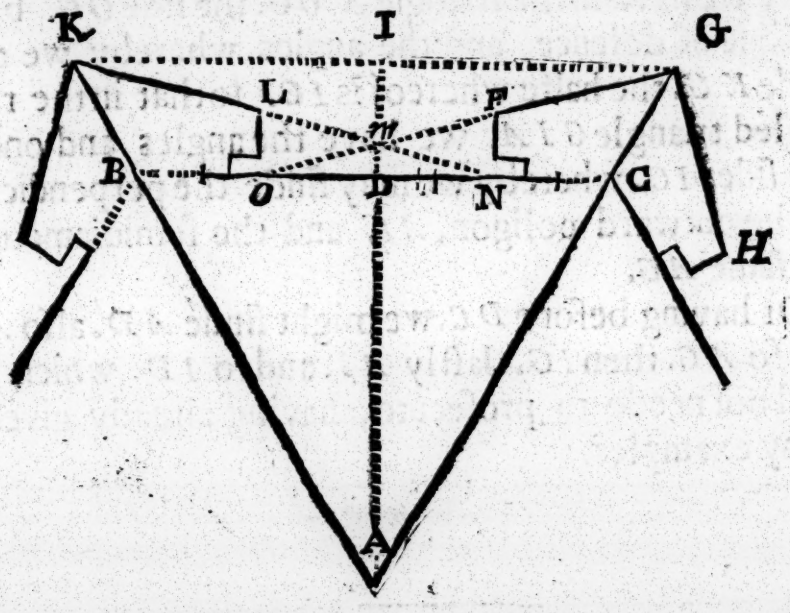
Or having before *D C.* we might finde *A D.* alſo *A C.* and ſo *A G.* then *I G.* laſtly *A I.* and ſo *I D.* which we ſhall not neede to proſecute, having already given ſo many examples.

THE

THE SPANISH FORTIFICATION

with Casemates.

DIvide the side of the inward poligon *B C.* into 8. equall parts, and let the Gorge-lines *O B.* and *N C.* be either of them two of those parts, and the flankes *O L.* and *N F.* either of them one of those parts, and perpendicular to the curtaines; and let the lines of



defence *O G.* and *N K.* be drawne from the angles of the flankes *O.* and *N.* by the shoulders *F.* and *L.* till they concurre with the head-lines at the points *G* and *K.*

If then the quantity of some one of these lines be determi-

termined, we may finde the other ſides and angles of ſuch a fort.

As in this fort of ſixe ſides, let the line of defence *O G.* be 85. rods, and the other ſides and angles required, then foraſmuch as the curtaine *O N.* is foure ſuch parts as the flanke *N F.* is one therefore in the right angled triangle *O F N.* I ſay,

As the curtaine ——— *O N.* 4. parts. 9, 3979.
is in proportion to *Radius*
ſo is the flanke ——— *N F.* 1. part. 0, 0000.
to tang. the angle ——— t. *F O N.* 14. d. 62. 9,3979.
equall to the inward flanking angle ——— *I G M.* 14. 2.
whoſe complement is the angle ——— *I M G.* 75. 58.
which doubled is the outward flanking angle ——— *K M G.* 151. 56.
againe the inward flanking angle ——— *I G M.* 14. 02.
taken from halfe the angle of the poligon ——— *I G A.* 60. 00.
leaves halfe the flanked angle ——— *F G C.* 45. 58.
which doubled is the flanked angle ——— *F G H.* 91. 56.

In the triangle G O C.

As ſine halfe the angle of the poligon ——— s. *D C A.* 60. d. 06. 0, 0625.
to the line of defence ——— *O G.* 850. foote. 2, 9294.
ſo ſine the inward flanking angle ——— s. *G O C.* 14. d 62. 9,3947.
to the head-line ——— *C G.* 238. foote. 2,3766.

In the ſame triangle.

As ſine halfe the angle of the poligon ——— s. *D C A.* 60. d. 06. 0, 0625.
is to the line of defence ——— *O G* 850. foote. 2, 9294.
ſo ſine halfe the flanked angle ——— s. *O G C.* 45. 58. 9,8567.
to the line ——— *O C.* 705. 6. 2,8486.
A third part whereof is the gorge-line ——— *N C.* 235. 2.
which ſubſtracted, remains the curtaine ——— *O N.* 470. 4.
halfe the gorge-line is the flanke ——— *N F.* 117, 6.

In the triangle O F N.

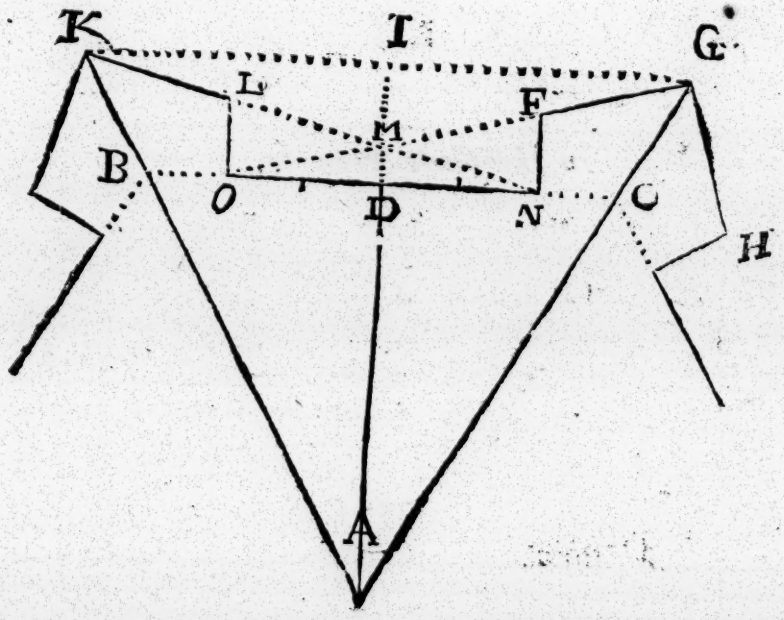
As the sine of the angle *I M G* or ——— s. *O F N.* 75. d. 58′. 0,0132.
is in proportion to the curtaine ——— *ON.* 470. 4. 2,6724.
so is sine 90. d. or *Radius*
to the distance of the shoulder ——— *O F.* 484. 9. 2,6856.
which substracted from the line of defence ——— *O G.* 850.
there remaines the front ——— *F G.* 365. 1.

Thus we might proceede to finde, ∠ *A D.* ∠ *A C.* ∠ *A G.* *IG.* ∠ *A I.* &c. but in this example being for an hexagon ∠ *A C.* is equall to *B C.* and ∠ *A G.* to *K G.*

Without Casemates.

Divide the side of the inward poligon *B C.* into 6. equall parts, and let the gorge-lines *N C.* and *B O.* and likewise the flankes *N F.* and *O L.* be every of them one of those parts, and the flankes perpendicular to the curtaine.

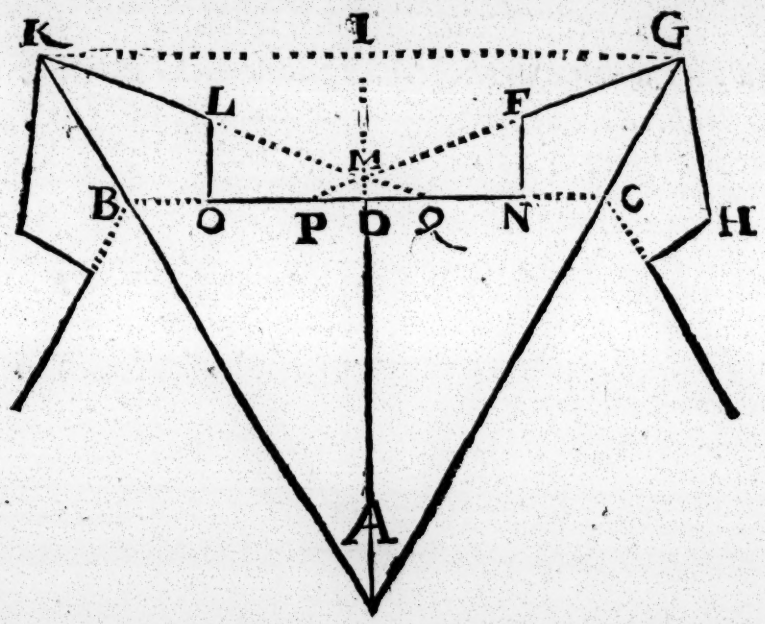
If then the quantity of some one of these lines bee determined in rods or feete, we may finde the quantity of all the other sides and angles, in such a sort, as in the former example.



THE VENETIAN FORTIFICATION.

MAke the Gorge-lines *N C.* and *O B.* and alſo thē flankes *N F.* and *O L.* ēvery of them a ſixth part of the ſide of the inner poligon. *B C.* that is a ſixt part of the diſtance of the centers of the bulworkes.

And furthēr make the ſecond flankes *O P.* and *Q N.* to be either of them a third part of thē curtaine *O N.*



In ſuch forts as havē not abovē ſeven ſides, but in thoſe that have more than ſeven ſides you may makē the ſecond flankes to be either of them one halfe of thē curtaine.

The side of the inner poligon B C. exceedes not 100. rods, nor is lesse than 75. rods.

If therefore the measure of any of these parts be given in rods or feete, we may finde the quantity of the other sides and angles.

As admit the side of the inner poligon B C. to be 78. rods, and let there be required the other sides and angles: *Then seeing*

The side of the inward poligon is —— B C. 78. rods.
a sixt part thereof is the gorge-line —— N C. 13.
to which is equall the flanke —— N F. 13.
the sum of them both doubled is the gorgeline — 26.
which taken from B C. *leaves the curtaine* O N. 52.
a third part whereof is the second flanke — O P. 17 1/3.
which doubled is the line —— P N. 34 2/3.
whereto adding the gorge-line —— N C. 13.
we have the line —— P C. 47 2/3.

Thus then in the right angle triangle. P N F.

As the foresayd line —— P N. 346. 7. 7, 4601.
is in proportion to Radius
so is the flanke —— F N. 130. 2, 1139.
to the tangent of the angle — t. F P N. 20. d. 33. 9. 5740.
whereto is equall the angle —— I G M. 20. 33.
which substracted from halfe the angle of the poligon (which here suppose to be a hexagon) I G A. 60. d. 00.
there remaines halfe the flanked angle F G C. 39. 27.
which doubled is the flanked angle — F G H. 78. 54.
also to the angle before found —— F P N. 20. d. 33.
adding a right angle or —— 90. d. 00.
we have the angle of the shoulder — N F G. 110. 33.

In

In the ſame triangle PNF.

As the ſine of the angle ——— s. *F P N.* 20.d. 33'. 0,4547.
is in proportion to the flanke ——— *F N.* 130. foote. 2,1139.
ſo is *Radius*
to the line ——— *P F.* 370.3. 2,5686.

In the triangle PGC:

As the ſine of halfe the flanked angle ——— s. *P G C.* 39. d. 27'. 0,1969.
is in proportion to the line ——— *P C.* 470. 7. 2,6727.
ſo ſine halfe the angle of the poligon ——— s. *D C A.* 60. d. 00 9.9375.
to the ſhorteſt line of defence ——— *P G.* 641. 4. 2,8071.
from which ſubſtracting the line ——— *P F.* 370. 3.
there remaines the front ——— *F G.* 271. 1.

And thus we might proceede to finde the perpendiculars AD. *and* AI. *and ſo the diſtance of the poligons* ID. *which cannot be obſcure to him that underſtands the former examples, therefore we paſſe over this.*

The Fortification uſed by the *Holanders*, we have before handled more largely.

CHAP. VII.

Of drawing the platforme of a Fort, and marking out the same on the ground, and of fitting an instrument for that purpose.

I Intend not here to handle all parts of the Art of Fortification at large, that being done by others: but rather to shew therein the application or use of this new invention of logarithmes in unfolding the principall mysteries of this Art with much more ease and expedition then by any way of like certainety formerly used: Yet because there is very little written of this subject in our language; and that the things we shall after speake of may be the better understood, I will give an example how to delineate the ground worke of a Fort first on paper, and then how to stake or marke out the same on the ground where such a Fort is intended, and lastly wee shall speake of the workes that are to be raised on such a groundworke, and first for the plat.

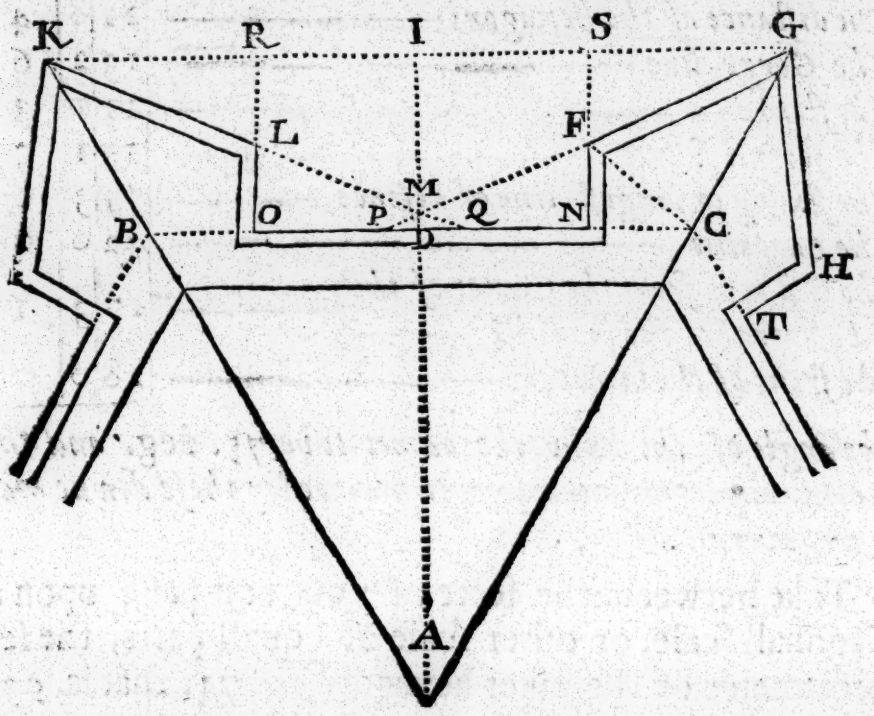
As admit it be required to draw the platforme of a regular Fort of sixe sides or bulworkes, according to some proportion assigned: First then you may finde as hath before beene shewed, the angles sides and other lines in such a Fort requisite to be knowne, which admit to be as followeth, in rods, feete, and tenth parts of feete.

	ro.	f.	ten.
The ſemidiameter of the outer hexagon	93	7	4
The ſide of the outer hexagon	93	7	4
The head-line	25	2	2
The ſemidiameter of the inner hexagon	68	5	2
The ſide of the inner hexagon as much	68	5	2
The diſtance of the hexagons	21	8	4
The Gorge-line	13	2	6
The flanke	11	1	3
The ſecond flanke	15	1	3
The fixing or longeſt line of defence	71	3	0
The Curtaine	42	0	0
The diſtance from the Center of the bulworke to the ſhoulder	17	3	1
The front of the bulworke	28	0	0

The angle of the bulworke admit to be 75. deg. *and the other angles anſwerable, then may we lay theſe downe many ſeverall wayes.*

Take betweene the feete of your compaſſe upon a diagonall ſcale, or other ſcale of equall parts, the ſemidiameter of the outer hexagon 93. 74. that is, 93. rods, 7. foote, and 4. tenthes of a foote, or 93. rods and 74. centeſmes of a rod, and ſuppoſing *A.* to be the center of the Fort, upon the point *A.* and diſtance *A G.* deſcribe a circle, and becauſe the ſide of a hexagon is equall to the ſemidiameter, ſet in the circumference the ſame meaſure 93. 74. from *G.* to *K.* and ſo *G.* is the diamond point of one bulworke, and *K.* of another, and draw the lines *A G.* and *A K.* Then taking the ſemidiameter of the inner hexagon. 68. 52. ſet the ſame from *A.* to *B.* and *C.* ſo *B.* and *C.* are the centers of two bulworkes,

workes, and drawing the line *B C.* ſet downe the gorge-line, 13. 26. from *B.* to *O.* and from *C.* to *N.* the reſidue of which line namely *O N.* is the curtaine, to which on thoſe parts O. and *N.* raiſe the perpendiculars, *N. F.* and O. *L.* for the flankes, which flankes may be ſet off



according to the foreſayd meaſure of 11. 13. or otherwiſe ſet off in the curtaine from O. to *P.* and from *N.* to *Q.* 15. 13. for the ſecond flankes, and drawing the ſhorteſt line of defence *P G. Q K.* they interſect the perpendiculars raiſed for the firſt flankes in the points *L.* and *F.* and ſo is *N. F.* the flanke, *F. G.* the Front, and in like ſort we may proceede, with the other ſides of this Fort.

Otherwiſe having drawne the line *K G.* ſet downe in the

the ſame the ſide of the outer hexagon, 93. 74. from *K* to *G*. as before, which is the diſtance of the angular points or heads of the bulworkes, then to the right line *K G*. and to the points in the ſame *K*. and *G*. deſcribe the angles *B K G*. and *C G K*. here in the preſent example, each of 60. deg. and in the lines *K B*. and *G C*. ſet off from *K*. and *G*. 25. 22. for the head-lines, which ending at *B*. and *C*. thoſe points *B*. and *C*. are the centers of the bulworkes, wherefore drawing the line *B C*. proceede as before.

Otherwiſe let *K*. and *G*. be the angular points of two of the bulworkes, draw the line *K G*. and on the points *K*. and *G*. deſcribe the angles *A K G*. and *A G K*. (each in this example 60. deg.) and ſet off from *K*. to *B*. and from *G*. to *C*. the head-lines *K B*. and *G C*. drawing as before the line *B C*. then to the line *B C*. and to the point in the ſame *C*. deſcribe the angle *F C N*. of 40. deg. alſo to the line *G A*. and to the point in the ſame *G*. deſcribe halfe the flanked angle *F G C*. which is here 37. deg. 30. and at the concourſe of theſe lines, *C F*. and *G F*. namely at *F*. is the ſhoulder of the bulworke, from which letting fall to the curtaine the perpendicular *F N*. that line *F N*. is the flanke, *N C*. the Gorge-line, *N O*. the curtaine, *F G*. the front, &c. and ſo are the more eſſentiall parts of this Fort deſcribed. Sundry other wayes might be ſhewed, which being of themſelves very eaſie, we over paſſe; neither ſpeake we of the ſcale, which may be the plaine ſcale or ſector, nor of taking the degrees, or parts on that ſcale, ſuppoſing you are already ſo farre initiated in Geometricall practiſes.

Of marking it out on the ground.

In like ſort, when you would marke out any ſuch Fort on the ground, you may place your inſtrument there where you intend the center of your Fort, as at *A*. and from thence ſet out all the angles at the center, according to the number of the ſides of that Fort, which in this example being 6. thoſe angles alſo are 6. and every of them 60. degrees, which angles ſet forth by the right lines, *A K*. *A G*. &c. and in every of thoſe right lines meaſure by a chaine, divided and ſubdivided into rods and feete, &c. the ſemidiameters of the outward and inward poligons, which here are *A C*. 68. 5. 2. that is 68. rods, 5. foote, and 2. tenthes of a foote, and *A G*. 93. 7. 4. ſetting ſtakes at the end of thoſe meaſures, and theſe are the diſtances of the centers, and heads or angular points of every bulworke, from the center of the Fort, and being all ſtaked out, if you will examine your worke, you may meaſure round about from ſtake to ſtake, the ſides of the outer and inner poligons, or of the outer poligon onely, for the line on the ground from the ſtake at *K*. to the ſtake at *G*. is the ſide of the outer poligon, and the line from the ſtake at *B*. to that at *C*. is the ſide of the inner poligon. You may therefore place your inſtrument at the ſtake *C*. and thereby draw a line on the ground *F C*. making the angle forming the flanke namely the angle, *F C B*. 40. deg. and the line *F C*. (in this example) 17. 3. 1. and there ſet a ſtake at *F*. for one ſhoulder of the bulworke. Or otherwiſe from the ſtake *C*. towards the ſtake at *B*. meaſure the Gorge-line *C N*. (here 13. 2. 6.) and ſet a ſtake at *N*.

for

for the end of the curtaine, from which measuring forwards, towards *B*. 15. 1. 3. that is 15. rods, 1. foote, 3. tenths of a foote, further to Q. there drive a stake, terminating the second flanke, and doe the like from the stake at *B*. towards *C*. then from the stake at the angular point of the bulworke *G*. measure towards the stake at *P*. 28. rods, and there drive a stake at *F*. from which the flanke falls perpendicularly to *N*. and in like sort you may set out the other halfe of the bulworke, *K L O B*. and so is there one side of the Fort staked out, the other sides are all to be set out after the same manner.

The same another way.

Otherwise let *K*. and *G*. represent two stakes on the ground, where you intend shall be the heads or angular points of two bulworkes, then placing your instrument at *G*. by helpe thereof you may line out on the ground, half the angle of the poligon *K G A*. which in this example of an hexagon, is 60. deg. also halfe the angle of the bulworke, *F G C*. which here is 37. deg. 30. and in the line *G A*. measure the head-line *G C*. setting a stake at *C*. for the center of the bulworke, the like you may doe from *K*. driving a stake at *B*. the center of that bulworke. Then placing your instrument at *C*. strike a line on the ground *F C*. making with the line *B C*. an angle of 40. d. and where it concurres with the line *G F*. namely at *F*. there drive a stake for that shoulder of the bulworke, and from *F*. let fall by your instrument a line on the ground *F N*. perpendicular to the line *B C*. and the like you may doe from *B*. and *L*. And

thus the lines betweene the ſtakes *G F.* and *K L.* doe limit the fronts, the lines from the ſtakes *F N.* and *L O.* the flankes, the lines betweene the ſtakes *N C.* and *B O.* the Gorge lines, and from *O.* to *N.* the curtaine, and in like ſort you may proceede, with all the other ſides of this hexagon, and ſo of any other figure.

Sundry other wayes for lyning out a Fort, might be preſcribed, which he that is exerciſed in Geometricall menſurations, will of himſelfe eaſily conceive.

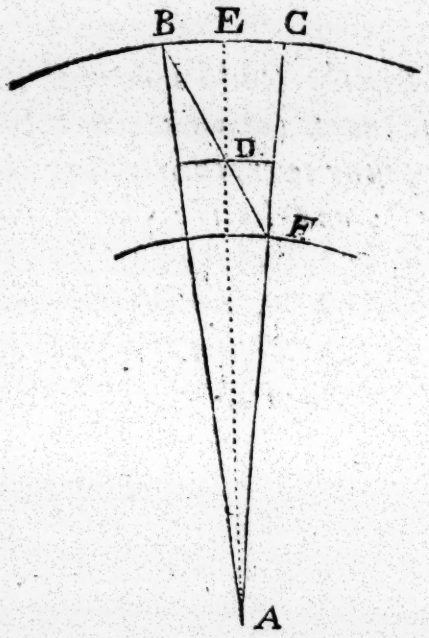
But before you begin to breake ground, examine all the parts which you have thus ſtaked out, by the other meaſures ſet downe in the tables of the fifth chapter, or by the parts calculated, as we have before ſhewed, and conſider all diligently a weeke or more, if time will permit, that ſo if any thing may be amended, it may bee done before you proceed any further.

The Inſtrument fitteſt for lyning out a Fort is the *Theodelite*, or ſome other inſtrument of that nature, the limbe thereof being divided into degrees, and every degree ſubdivided into *6.* 10. 12. 20. 30. or 60. parts, that ſo you may readily count the minutes. The diameter of your Theodelite may be two foote or more, eſpecially if it be of wood, but they are commonly made much leſſe, and the degrees in them, as alſo in ſemicircles, quadrants, and the like, ſubdivided by diagonals, the intermediate circles of thoſe diagonalls, being equally diſtant one from another, which is erronious, eſpecially if the inſtrument be ſmall, the ſpaces great, and the diagonall broad: and becauſe this errour is very common, and not touched by any ſo farre as I know, it will not bee altogether impertinent in this place

place to shew how by plainē triangles it may bē reformed.

To subdivide the degrees, or other parts of the Theodelite, semicircle, quadrant, or other circumference, by a diagonall scale.

Let *A B.* be the semidiameter of the outermost circle *A F.* the semidiamiter of the innermost, and I would divide the arch *B C.* or the angle *B A C.* into two equall parts, by the diagonall *B F.* there is required the semidiameter of the intermediatē circle, cutting the diagonall *B F.* so as the parts of it may subtend equall angles at *A.* divide the arch *B C.* into two equall parts in the point *E.* and draw the right line *A E.* which intersects the diagonall *B F.* in the point *D.* then doe the parts of the diagonall line *B D.* and *D F.* subtend equall angles, namely *B A D.* and *D A F.* if therefore on the center *A.* and distance *A D.* there be a circle described it will cut the diagonall *B F.* as is required.



But to finde this distancē or semidiameter *A D.* by thē Doctrine of triangles; first having determined the

greatest and least semidiameters *A B.* and *A F.* and their contained angle *B A F.* we may finde by the tenth case of plaine triangles the angle *A B F.* which being known we have in the triangle *A B D.* the side *A B.* and the angles *A B D.* and *D A B.* wherefore by the eighth case we may finde the side *A D.* and so you may proceede by the sayd eighth case to finde the semidiameters of any other intermediate circles for dividing the angle *B A F.* into as many equall parts as you will.

Example.

Let the semidiameter of the outermost circle A B. *be sixe inches (of which size they are often made in brasse) and supposing every inch to containe* 1000. *parts this is* 6000. *parts; and let the semidiameter of the innermost circle* A F. *be* 4. *inches or* 4000. *parts, and the arch* B C. *or the angle* B A C. *one degree, which we would divide into twelve equall parts, by a diagonall, so that every part may be five minutes.*

I say then

As the summe of the semidiameters	*A B. + A F.*	10000. 6, 00000.
is in proportion to their difference	*A B. — A F.*	2000. 3, 30103.
so the tang. of the halfe summe	t. $\frac{1}{2}$. *F. + B.* 89. d. 36.	12, 05914.
to the tangent of an angle	t. 87. 36. 6″6.	11, 36017.
which substracted there remaines	*A B F.* 1. d. 59′. 54″.	

And seeing the angle B A C. *is* 1. deg. *or* 60. *minutes and it is required to divide it into twelve parts, every part will be* 5. *minutes, wherefore supposing the angle* B A D. *to represent that angle of* 5. *minutes, and* A B D. 1. deg. 59.

59. minuits 54". the ſum of them is —— 2. d. 64. 54".
the complement of the angle B D A. *to* 180. deg. *which ſo encreaſeth for every twelfth part* 5. *minutes.*

I ſay then

As the ſine of the angle —	s. *B D E.* 2. d. 64. 54".	1,43980.
to the greateſt ſemidiameter	*A B.* 6000. parts.	3,77815.
ſo the ſine of the angle at *B.*	s. *B.* 1. d. 59'. 54".	8,54246.
to the firſt and leſſer ſemidiameter	5760.	3,76041.

And thus we might proceede to finde all the other ſemidiameters, by adding to the complements arithmeticall of the ſines of the ſeverall angles at *D.* the ſumme of the ſecond and third namely 12, 32061. ſo ſhall you have the logarithmes of theſe numbers following, being the ſemidiameters of the intermediate circles.

Angle A. in, m.	*Semidia. in parts.*
0	6000
5	5760
10	5538
15	5333
20	5143
25	4965
30	4799
35	4644
40	4499
45	4363
50	4234
55	4113
60	4000

But in this example, and much more in others where a degree or leſſe is ſubdivided into ſmaller parts, the angles of the triangles being very ſmall, we neede not uſe the ſines of the angles, but the angles themſelves reduced into minutes or ſeconds, for in theſe the ſines of ſeverall angles, and the angles themſelves have the ſame proportion, without ſenſible difference: that is,

As the ſine of ——	1. d. 00.
to the ſine of ——	0. d. 30.
ſo is ——	60.
to ——	30.

And

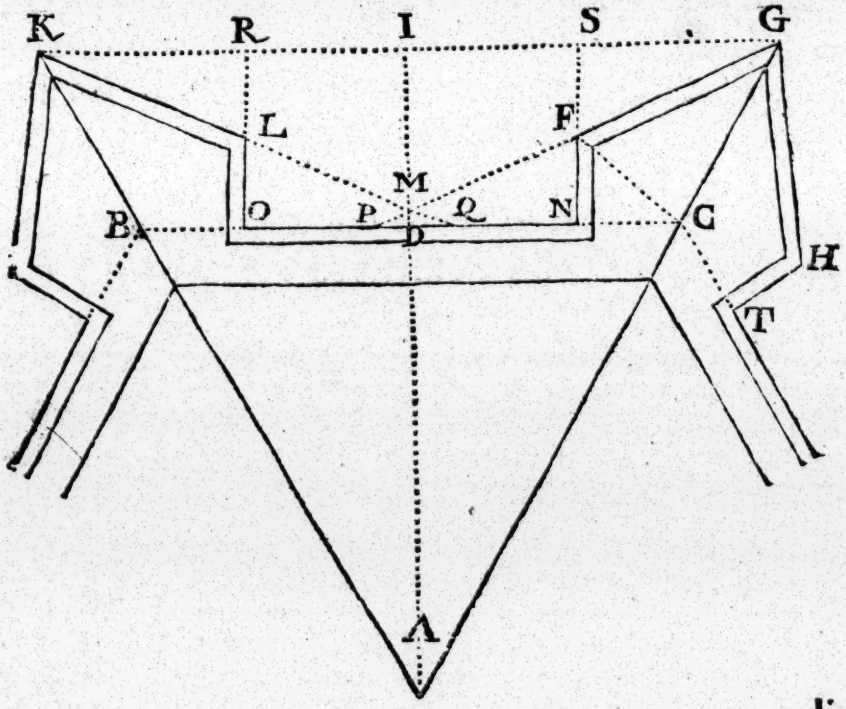
And ſo of others; But this by the way, now we returne from whence we have digreſſed.

CHAP. VIII.

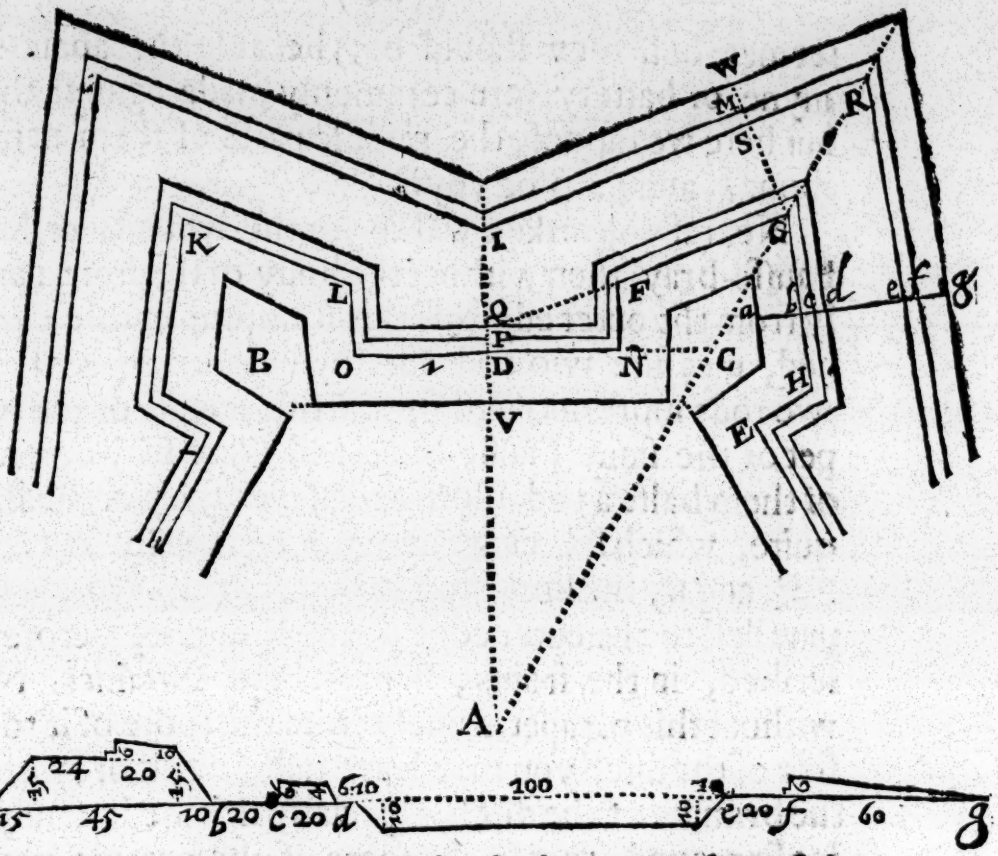
Shewing how and in what forme, the Rampire, and Parapets are to be raiſed, and the Ditch to be ſunke.

WE have ſhewed in the Chapter laſt before going, how to delineate the platforme of a Fort, and alſo how to ſtake out the ſame upon the ground, we will proceede briefely to touch the reſt.

Firſt then it is to be underſtood that that which you have drawne, as before we have ſhewed, namely the



lines



lines *KL.LO.ON.NF.FG. &c.* is the outer edge of the Rampire, (as in this figure above) which Rampire may be in breadth or thicknes inwardly 7. rods, or somewhat more or lesse as occasion requirs, for in a Fort of 12. sides or more, & of importance answerable, it may be 10. rods, and in a Fort of 4 bulworkes, being of lesse importance if it be 5. rods, it may be sufficient, and in small skonces much lesse, which thickenesse is here represented by *DV.* so that the line drawne by *V.* doth represent the inward side of the Rampire, being in the curtaine, flanke, and front, every where parallell or equidistant to the outside of the Rampire before described; Yet sometimes the bulworkes are quite filled up, and (so it

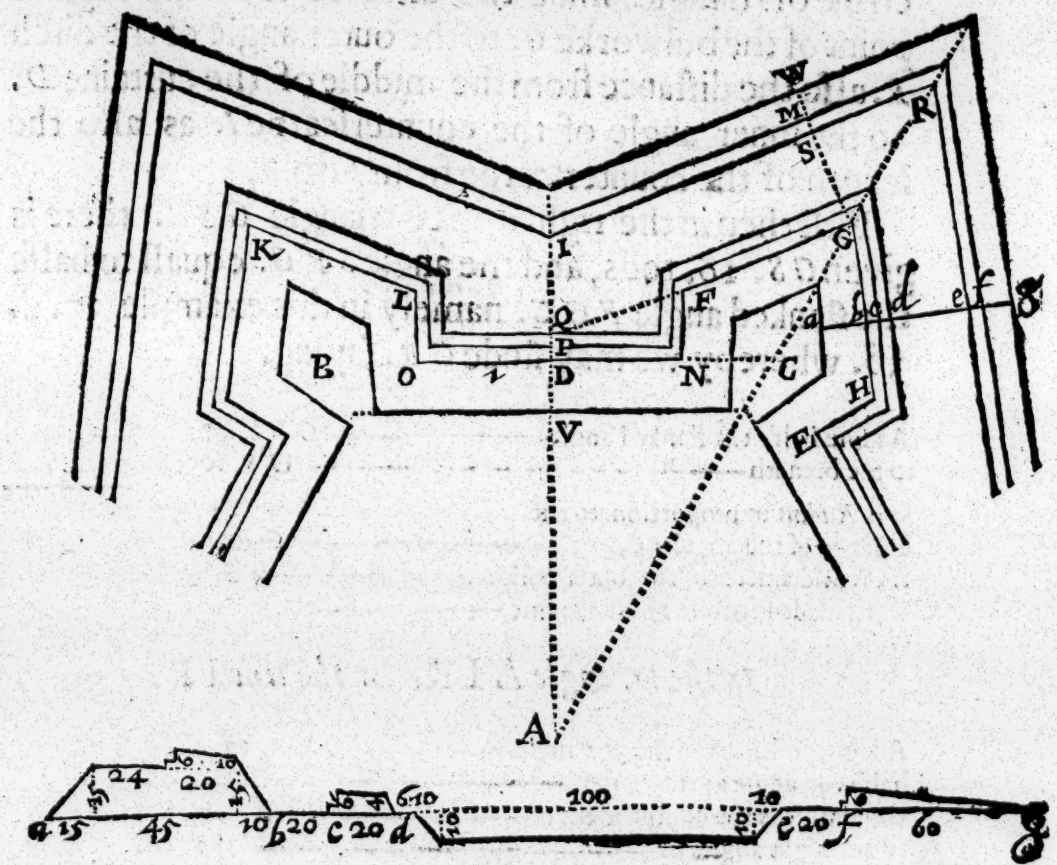
ſeemes beſt they ſhould be,) becauſe the aſſaults by myne or battery, are commonly made againſt them, but here we ſuppoſe the middle parts of them namely about *B.* and *C.* to be voyd.

Next if you make a walke for the Rounds called a Fauſſe-bray, then without the body of the Fort, namely from the outer edge of the Rampire before deſcribed, meaſure two rods for the breadth thereof, and two rods more outward for the thickeneſſe of the parapet of the ſame Fauſſe-bray, and theſe may be either of them halfe a rod, more or leſſe, as the place ſhall require, which ſpaces are here repreſented by *D P.* and *P Q.* and by the lines drawne by *P.* and *Q.* every where parallell to the outer edge of the Rampire, before deſcribed, in the fronts, flankes, and curtaines. Next without this parapet, namely from the foote of it to the ſide of the ditch you may leave halfe a rod or more for the brimme of the ditch, eſpecially if it be in ſandy or looſe ground, that ſo the foote of the parapet may be the more firme. And theſe are the things to be ſet out within the ditch, which you are to marke out on the ground accordingly. The Port or Ports, are beſt to be made in the middle of the curtaine, for ſo they are defended from two flankes, and are to be placed as low as may be to avoyd any battery, that may be made againſt them, and a wooden bridge over the ditch, with gates and drawbridges in ſeverall parts thereof.

Then may you ſet out the breadth of the ditch which may be 12. rods, or more or leſſe, as occaſion requires, for if the ground be low, ſo that you cannot digge deepe, by reaſon of the water, the ditch muſt be the larger, that there may be a ſufficient quantity of earth for

for the Rampire and Parapets, therefore to the front of the bulworke *F G.* and to the point *G.* being the angular point of the bulworke, raiſe the perpendicular *G S.* and becauſe the fauſſebray with the parapet thereof is in breadth 4. rods, and in this example we make the ditch 12. rods broad, therefore make the line *G S.* 16. rods, and by the point *S.* draw *R S I.* the outer edge of the ditch, which here is parallel to the front of the bulworke *G F.* but is ſometimes ſo drawne that it comes more inward againſt the middle of the curtaine at *I.* then at *R.* by a rod or two.

Next without the ditch muſt be the coridor or covert way of the counterſcarpe whoſe breadth from the ſide



M 2 of

of the ditch may be two rods, or thereabouts, which is here represented by the space *S M*. and without that covert way, must be an argin or parapet 5. or 6. rods broad, represented by *M. W*. And all these namely the counterscarpe, or outer edge of the ditch, the covert way and the parapet thereof are in such sort to be continued round about the Fort, so that as we have shewed to draw one side from the point *I*. against the middle of the curtaine to the point *R*. against the angular point of the bulworke, the like is to be done for all the rest.

Now that the outer edge of the ditch *R S I*. may be the more truely drawne and set out, we may by the doctrine of triangles finde the distance from the angular point of the bulworke *G*. to the outer angle of the ditch *R*. also the distance from the middle of the curtaine *D*. to the inner angle of the counterscarpe *I*. as also the length of the counterscarpe from *I*. to *R*.

First then in the right angled triangle *G S R*. there is given *G S*. 16. rods, and the angle *S R G*. equall to halfe the flanked angle *F G C*. namely in this example 37. d. 36. whereby we may finde *G R*. saying.

As sine halfe the flanked angle	*G R S*. 37. d. 36.	0,2156.
to the breadth	*G S*. 160. foote.	2,2041.
so is *Radius* in proportion to the distance of the angular points	*G R*. 262. 8.	2,4197.
the semidiameter of the outer poligon	*A G*. 937. 4.	
which added together give the line	*A R*. 1200. 2.	

In the triangle A I R. *for the line* I R.

Adding to halfe the flanked angle	*I R A*. 37. d. 30.	
halfe the angle at the center	*I A R*. 30. 00.	
the summe is the complement of	*A I R*. 67. 30.	
to two right angles or	180. 00.	

Therefore

Therefore

As the ſine of the angle	*A I R.* s. 67. d. 36.	0,0344.
to the lin before found	*A R.* 1200. 2.	3,0793.
ſo ſine halfe the angle at the center	s. *I A R.* 30. 06.	9,6989.
to the outer edge of the ditch	*I R.* 649. 5.	2,8126.

Laſtly for I D.

As ſine the angle	s. *A I R.* 67. d. 36.	0,0344.
to the line before found	*A R* 1200. 2.	3,0793.
ſo ſine halfe the flanked angle	s. *I R A.* 37. d. 36.	9,7844.
to the line	*A I.* 790. 8.	2,8981.
from which taking the leſſer perpendicular	*A D.* 593. 4.	
there remaines the diſtance	*D I.* 197. 4.	

And ſo farre is that inner angle of the counterſcarpe from the outſide of the Rampire in the middle of the curtaine.

The true meaſure of theſe lines being thus found, they may the more exactly be ſet out.

And thus much touching the delineation of the platforme of a Fort, and the marking of it out upon the ground; we come next to ſpeake of the height of the Rampire and parapets and of the depth of the ditch.

The Rampire and parapets wee ſuppoſe to be raiſed of earth taken out of the ditch; touching the forme of the workes, in height, depth, and ſcarping; that it may be the better conceived, we draw the line *a b c d e f g.* croſſing the front of the bulworke, ditch, counterſcarpe, &c. at right angles, upon which line we may repreſent the breadth, heighth, depth, and ſcarpings,

of all the workes, which that it may be the more ſenſible we draw here apart a longer line, *a b c d e f g.* and on this line by a ſcale ſo large, that feete and parts of feete may be well diſcerned, firſt ſet downe the breadth of the Rampire, from *a* to *b.* 70. foote, the breadth of the fauſſebray *b c.* 20. foote, the breadth of the parapet thereof *c d.* 20. foote, leaving without it 5. or 6. foote for the brimme of the ditch, and from thence ſet off the breadth of the ditch to *e.* 120. foote, and without that the breadth of the covert way *e f.* 20. foote, and without that the breadth of the Argin or parapet thereof *f g.* 60. foote, and thus you have expreſſed in this line, the breadth of all the workes to be made.

Then betweene the points *a.* and *b.* the Rampire is to be raiſed which in Forts of foure ſides may be onely 12. foote high, but in a fort of 12. ſides or more, ſome would have to be 18. or 20. foote high; in this example we make it 15. foote high, for the too great height of it may be prejudiciall to the defendants, eſpecially when the aſſaylants ſhall approach neare the ditch. The Rampire is to be raiſed on either ſide ſcarping, namely on the outſide, for every two foote that it riſeth it may ſcarpe one, but here for every three foote that it riſeth it ſcarpes two, ſo that the toppe of it being 15. foote, ſcarpes 10. foote, and in ſome ſandy or looſe grounds it had neede to ſcarpe more. But the inner ſide of the Rampire next the Fort ſcarpes more, namely for every foote that it riſeth in heighth, it ſcarpes a foote, and being raiſed to his full height namely 15. foote, it hath alſo 15. foote ſcarpe, to the intent that the defendants may the more eaſily aſcend the Rampire in all parts as occaſion ſhall require, and thus

though

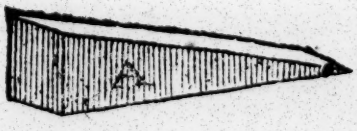
though the bottome of the Rampire *ab.* be 70. foote broad yet the upper ſuperficies of it is but 45. foote broad, and theſe are the breadth height, and ſcarpings of the Rampire round about the Fort: upon the outſide of the upper ſuperficies of the Rampire, is raiſed a parapet, ſometimes 24. ſometimes 15. foote broad or more or leſſe, here we make it 20. foote broad below, and on the inner ſide 6. foote high, with a foote ſcarpe, but outwardly not above foure foote high, within which parapet is a banke or foote paſe round about, being ſometimes two but here three foote broad, and a foote and halfe high. In like ſort is raiſed the parapet of the fauſſebray, and alſo that of the covert way, without the ditch, ſave that the outſide thereof is ſlanting or ſcarping about 60. foote till it be even with the champion about; all which may ſufficiently appeare by the figure *abcdefg.* which figure thus drawne wee may call the Section or Profile. Touching the ditch it is in this example 120. foote broad, and 10. foote deepe, either ſide of it ſcarping alſo tenne foote as by the Section appeares. And thus much of the workes to be made, and in what forme, now touching the manner, we will briefely ſet it downe out of S. *Marolois* his Fortification as followeth.

In the Netherlands when ſuch a worke is to be reſolved on, the Engineir drawes ſuch conditions as are to be obſerved, for the more ſpeedy accompliſhment of the worke, the time when it ſhall begin, and when it ought to be finiſhed, the number of workemen to bee uſually imployed, whether the foundation be to be piled and how: how many feete he will allow without

the foote of the Rampire for the Fauſſebray and its parapet and for the brimme of the ditch, the thickneſſe or breadth of every of them, what ſcarpe is to be given within and without, according to the faſtneſſe or looſeneſſe of the earth: how many fagots ſhall be layd if the ground be ſandy. In the parapet of the fauſſebray and in the Rampire, the height and ſcarpings inward and outward; the breadth depth and ſcarpings of the ditch, and all things elſe appertaining to the worke, and ſo gives notice in the townes nere adjoyning, that upon ſuch a day there are ſuch and ſuch workes to be let out to ſuch men as will undertake and performe them, beſt and beſt cheape. And upon the day appointed the undertakers being aſſembled, and the conditions and covenants read, according to which the buſineſſe is to be done. Queſtion is made who will undertake, and at the loweſt price, one of the undertakers offers to doe it ſo, another it may be for leſſe, and ſo at length till none will undertake it cheaper. Then under the articles of the conditions and covenants, he writes that ſuch an one hath undertaken that buſineſſe upon thoſe conditions, for ſuch a ſumme; ſometimes two or three men undertake the whole worke, and they all ſigne to the Articles, as alſo the Lords commiſſariſes, and the Engineir, and then the buſineſſe begins; and uſually the undertakers are bound by the ſayd Articles and contracts to finde the materialls neceſſary for the ſayd buſineſſe; which they receive of the keepers of the Magaſins or ſtore, reſpectively for that uſe, or otherwiſe under their cuſtody to be againe reſtored. Then the ſayd maſter undertaker, divides his men according as he conceives the quality of the buſineſſe doth

doth require: ſo many he aſſignes to digge, ſo many to drive the Carts, and others to lay the earth even: for at the beginng of the worke it ſeemes beſt to carry away the earth which is digged on the outſide of the ditch, with horſe and cart, to lay the foundation or bottome of the Rampire; and not with wheele-barrowes, as they doe afterwards when the worke begins to be rayſed to its height, and the ditches grow deepe, for then it is very hard to uſe horſe and cart becauſe the horſes ſpoyle the worke, and cannot be ſo conveniently employed as wheele-barrowes, which are driven upon plankes in good order and readineſſe, as any man may judge that hath beene preſent, where ſuch workes have beene made.

If the outſide of the Rampire be rayſed with turfe, it is to be underſtood that they be uſually 4. or 5. inches in breadth and as much at one end in thickeneſſe, and 14. or 15. inches long, but at the other end waxing ſharpe like a wedge, to the intent that betweene them there may be put a little earth, to make them hold the faſter to the body of the Rampire, their forme you may conceive by the figure *A*. Theſe turfes muſt be ſo layd that in every range upward, the middle of every turfe above, may lye juſtly upon the joyncture of every two turfes of the range next below, and ſo much aſlope as is anſwerable to the ſcarping intended and agreed upon, for the better performance whereof, they have a triangular inſtrument, the ſides thereof 2. or 3. foote long, and



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the angle contayned of thoſe ſides, ſuch as is anſwerable to the ſcarping intended, ſo as hanging a plumbline parallell to one ſide, the other ſide may be agreeable to the ſayd ſcarping. If you lay any fagots in the Rampire, they muſt be ſo layd that their ends may reach the former turfes, to wit, from halfe foote to half foote, for every halfe foote of earth muſt bee a range of fagots, and ſo continuing till the worke be finiſhed. Vpon the top of the Rampire the parapet is to be raiſed with ſuch ſcarpe and breadth as is before determined, (all in ſuch ſort as before,) rayſing it with turfes as above ſayd. If there be neere at hand any good earth, that is fat and clammy, then inſtead of turfes you may make a cruſt, of 3. or 4. foote or more, beating it well with a bat, made for that purpoſe, and ſhaping it with ſuch ſcarpe as is agreed upon: in which cruſt they ſow a certaine herbe, or the rootes thereof, called in *Flemiſh Queeckruit*, in *Latine Gramen*, and in *French Herbe de prais*, which roote hath the property to ſpread it ſelfe throughout the Rampire, and bindes it together in ſuch ſort, that it makes the ſayd cruſt endure very long, and become almoſt perpetuall. Alſo upon the ſayd cruſt, they ſow the ſeedes of Oates, Hay, or a certaine roote they call *Zevenbladeren*, or the roote of ſeven leafed graſſe, which is alſo very good, but theſe leaves doe not ſo cover the outſide of this cruſt, as doth the foreſayd herbe; for which cauſe his excellency hath of late yeares, repaired all the Fortifications, with ſuch a cruſt without turfe, becauſe experience ſhewes that the ſayd turfes doe not bind together with the reſt of the earth as that cruſt doth, which they uſe to moyſten, that it may mixe and cleave the better to the

Gramen, an herbe called Dogs-tooth Herbe *de Prais*. An hearbe Meddow-graſſe.

the earth of the Rampire, being ſo very commodious and of good expedition: thus farre *Moroloi*.

And becauſe ſome things touching the rayſing the with turfe, and laying fagots, are more diſtinctly ſet downe by our Countrey man Mr. *P. Ive*, (who ſeemes to have had experience in what he writes,) I have thought good to ſet downe his words as followeth.

The manner of the worke is this, the turfe muſt bee cut like a wedge of 12. or 14. inches long, and 5. or 6. inches broad, equidiſtant, the one end 4. or 5. inches thicke, and the other ſharpe, and theſe turfes would be taken in the beſt ground, that lyeth neere about the Fort, and muſt be cut with a long ſharpe ſpade, of 5. or 6. inches broade, and 14. inches long, which muſt bee well ſteeled, and kept very ſharpe, and the turfe muſt be carryed and handled without breaking, and layd in the worke, the great end outwards, and the graſſie ſide downeward, and ſcarping one foote in 5. or 6. feete; the Rampire behind the turfe riſing with the earth that is throwne out of the ditch, as faſt as the face of the worke riſeth; (And when the face is raiſed the height of 5. turfes, and the earth behind it layd even, and ſpread almoſt as broad as the Rampire is intended, (which may be 20. 30. or 40. foote or more or leſſe, as the earth throwne out of the ditch will make it) or at leaſt ſo broad, as it is thought that the wood will lye: for to ſay truth, to throw downe the earth, or to ſpread it too broad before the wall be rayſed, were a point of no great diſcretion) ſtretch a line and pare the turfe even with a ſharpe Spade, but ſcarping according to the firſt ſcarpe you layd them at, and then lay a row of

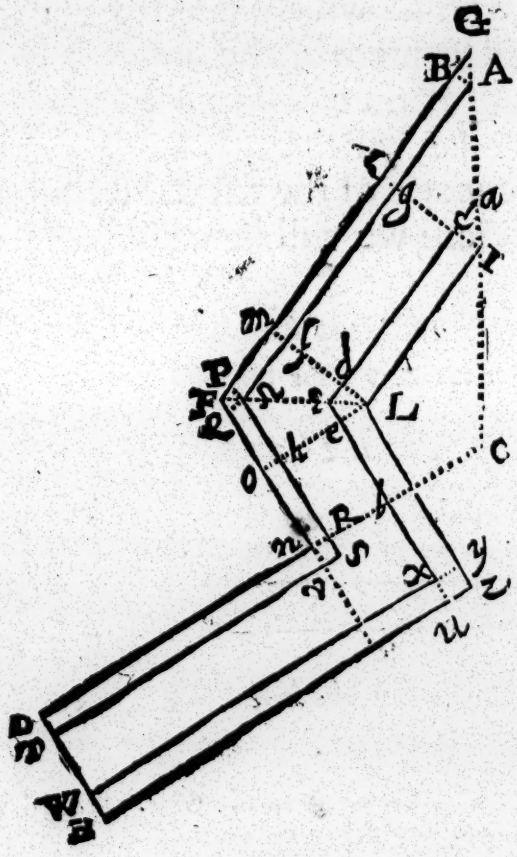
fagots, which fagots muſt be 8. or 9. foote long, more or leſſe as the wood will give them, but not thicker than that you may almoſt gripe them betweene your two hands, the great end of the wood lying all one way in the fagot, which end muſt be ſtamped againſt the ground, that it may lye even in the wall, and muſt be bound with three bonds, and layd in the worke, the great ends outwards, one inch over the turfe, and muſt be thruſt up faſt and cloſe, the one to the other, but not layd thicker than one fagot at once, and upon the ſmall end of thoſe firſt layd fagots, muſt other fagots be layd whoſe ſmall ends muſt over-lap the ſmall ends of the ſayd firſt fagots, ſome three foote and a halfe, or thereabouts; and upon the great ends of theſe ſecond fagots muſt a third fagot be layd, whoſe ſmall ends muſt likewiſe over-lap the great ends of the ſayd ſecond fagots, as the ſmall end of the ſecond did the ſmall ends of the firſt (and where wood is plenty having haſt to raiſe the worke, lay a fourth fagot in like manner) which being done, raiſe againe the face of the worke five turfes higher, paring it by a line as is aforeſayd, and rayſing the earth behind them as before, and then lay another row of fagots, and thus continue the worke untill it riſeth ſo high as you intend it. Where wood is ſcarce, there uſe none but in the bulwork onely, and there as little as you may, but onely to ſtay the face of the bulworke; and raiſe the face of the curtaine with turfes onely, giving them ſomewhat the more ſcarpe, or for a need uſe no wood at all.

CHAP.

CHAP. IX.

Of the quantity of earth for raising the Rampire and Parapets.

WHether the worke be let out at a certaine price to undertakers, as aforesayd or otherwise, it is required to know what quantity of earth will serve for all or any of the workes intended, wherefore let this figure be a twelfth



part of the hexagonall Fort before mentioned, *Chap.* 8. and let the line *G F.* represent the front 280. foote, *F n.* the flanke 111 ¼ foote, or 111. 25. *D n.* halfe the curtaine 210. foote: *D H.* the breadth of the Rampire at the foote which (as before we shewed) is in this example 70. foote, *D T.* the outward scarping 10. foote, *W H.* the inward scarping 15. foote, and so the breadth of the Rampire at the toppe or besides the scarpings *T W.* 45. foote. First then we will measure the crassitude of the Rampire without the scarpings as if it were above and beneath onely 45. foote broad, and afterwards cast up the content of the scarpings, both without and within, which added to the former will give us the solid content of this part of the Rampire, from the middle of the curtaine to the angular point of the next bulworke, which being knowne we shall easily finde the content of the whole Rampire round about, first therefore we will here shew

To find how much the Rampire is about at the foote, and also at the toppe, within and without.

For the line B G.

As *Radius* is in proportion to tang. compl. halfe the flanked angle	*B G A.* 37. d. 36. t.c.	10, 1150.
so is the outward scarpe	*A B* 10. foote.	1, 0000.
to the line	*B G.* 13. 03.	1, 1150.

For the line K G.

As *Radius* is in proportion to tang. compl. halfe the flanked angle	*B G A.* 37. d. 36. t.c.	10, 1150.
so is the thickenesse of the Rampire	*I K.* 70. foot.	1, 8451.
to the line	*K G.* 91. 22.	1, 9601.

For

For the line ca.

As *Radius* is in proportion
to tang. compl. halfe the flanked angle — *c a i.* 37. d. 30. t. c. 10,1150.
ſo is the inward ſcarpe — I C. 15. foote. 1,1761.
to the line — *c a.* 19. 55. 1,2911.

For the line FP.

As *Radius* is in proportion
to tang. compl. halfe the angle of the ſhoulder. *P F* Ω. 56. d. 15'. t. c 9,8249.
ſo is the outward ſcarpe — *P A.* 10. foote. 1,0000.
to the line — *F P.* 6. 68. 0,8249.

For the line. F *m.*

As *Radius* is in proportion
to tang. compl. halfe the angle of the ſhoulder *m F L.* 56. d. 15. t. c. 9,8249.
ſo is the breadth of the rampire — *L m.* 70. foote. 1,8451.
to the line — *F m.* 46. 77. 1,6700.

For the line ed.

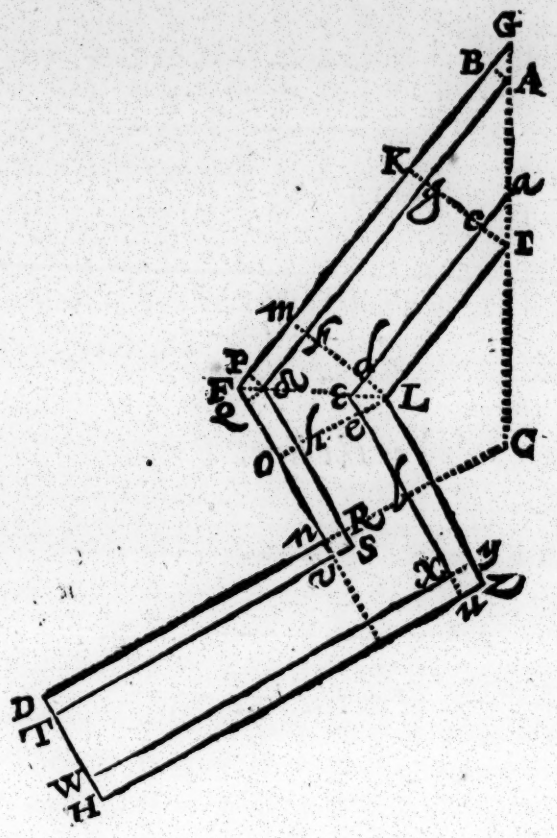
As *Radius* is in proportion
to tang. compl. halfe the angle of the ſhoulder — *de L.* 56. d. 15. t. c. 9,8249.
ſo is the inward ſcarpe — *L d.* 15. foote. 1, 1761.
to the line — *e d.* 10,02. 1,0010.

For A Ω.

Thus then we have the line — *B G.* 13. 03.
and the line — *F P.* 6. 68.
the ſumme of them both is — 19. 71.
which ſubſtracted from the front — *F G.* 280. foote.
there remaines the line — Ω. 260. 29.

For Ω S.

And if from the flanke — *F N.* 111. 25.
we ſubſtract *F* Q which is equall to — *F P.* 6. 68.
there remaines the line — Q*n.* 104. 57.
whereto adding the ſcarpe — *N v.* 10.
we have the line — *A S.* 114. 57.



For S T.

And if to halfe the curtaine	*n N.* 210. foote
we adde the ſcarpe	*N R.* 10. foote.
we have the line	*S T.* 220. foote.
to which adding the line	*Ω S.* 114. 57.
alſo the line	*A Ω* 260. 29.
we have the outer compaſſe	*A Ω S T.* 594.86.

For the line L I:

We found before the line	*K G.* 91. 22.
and the line	*F m.* 46 77.
the ſumme of them both is	137. 99.
which ſubſtracted from the front	*F G.* 280. foote.
there remaines the line	*L I.* 142. 1.

For

For the line L Z.

Againe the line *F O.* being equall to ——— *F N.* 46. 77.
ſubſtracted from the flanke ——— *F N.* 111. 25.
there remaines the line ——— *O N.* 64. 48.
whereto adding the thickeneſſe of the Rampire ——— 70.
the ſumme is the line ——— *L Z.* 134. 48.

For H Z.

And if to halfe the curtaine ——— *D N.* 210. foote.
we adde the thickeneſſe of the Rampire ——— 70. foote.
we have the line ——— *H Z.* 280. foote.

For the line a e.

And ſeeing to the line *L l.* is equall ——— *d c.* 142. 01.
to which adding the line ——— *c a.* 19. 55.
and alſo the line ——— *e d.* 10. 02.
the ſumme of theſe three is the line ——— *a e.* 171. 58.

For the line EX.

Alſo to the line *L Z.* before found is equall ——— *e u.* 134. 48.
whereto adding ——— *E e.* 10. 02.
the ſumme is the line ——— *E u.* 144. 50.
from which taking the ſcarpe ——— *X u.* 15. 00.
there remaines the line ——— *e X.* 129. 50.

For the line W X.

Alſo we found before the line ——— *H Z.* 280. foote.
from which ſubſtracting the ſcarpe ——— *u Z.* 15. foote.
there remaines the line ——— *W X.* 265. foote.
whereunto adding the before found ——— *a E.* 171. 58.
as alſo the line before found ——— *e X.* 129. 50.
we have the inner compaſſe ——— *a e X W.*

For the ſolid content of the Tere-plein or of the Rampire the ſcarpings excepted.

Thus we have the outer compaſſe of the upper part of the Rampire	A Ω S T. 594. 86.
Alſo the inner compaſſe	a ε X W. 566. 08.
the ſumme of them both is	1160. 94.
the halfe whereof is	580. 47. 2,7637798.
which multiplyed by the breadth	T W. 45. 1,6532125.
and the product by the height of the Rampire	15. 1, 1760912.
produceth the ſolid content of the Rampire the ſcarpings excepted, namely	391817. ſeete. 5, 5930835.

Note.

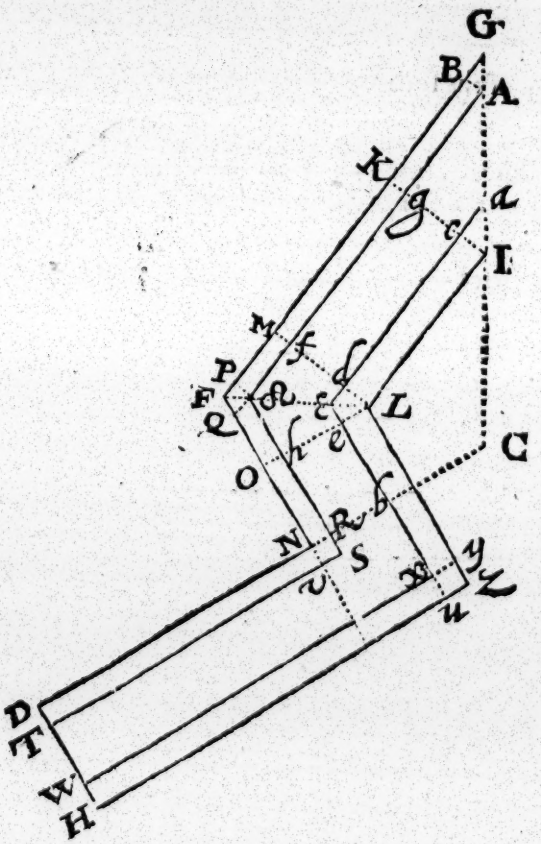
This product you may finde multiplying after the ordinary manner; or if you worke by logarithmes, you have here an example, but if the numbers be very great, as this laſt which exceeds all tables of logarithmes, you may worke by the part proportionall, as we have ſhewed Chap. 2. Booke 1. *of* Plaine triangles.

For the ſolid content of the ſcarpings.

Againe to the line	A Ω. 260. 29.
adding the line Ω R. or	Q N. 104. 57.
and alſo the line	N D. 210.
The ſumme of them is	574. 86 2,7595621.
which multiplyed by the outward ſcarpe	T D. 10. 1,0000000.
produceth the area	5758. 60. 3,7595621.

Furthermore

Furthermore to the line	*IL.* 142. 01.	
adding the line	*eX.* 129. 50.	
and alſo the line	*WX.* 265.	
the ſumme is	536. 51.	2,7955778.
which multiplyed by the inner ſcarpe	*WH.* 15.	1,1100912.
produceth the area	8047. 65.	3,9056690.
whereunto adding the area before found	5748. 60.	
the ſumme is	13796. 25.	
the halfe whereof is	6898. 12.	3,8387307.
which multiplyed by the height of the Rampire	15.	1,1760912.
produceth the ſolid content of the outward and inward ſcarpings of the Rampire,		5,0148219.
the pyramids in the corners excepted	103472. cub. feet.	



For the Pyramides in the angles.

Also multiplying the line ——— B G. 13. 03. 1,11502.
by the outward scarpe ——— A B. 10. 1,00000.
the product is ——— 130. 30. 2,11502.
halfe whereof is the area of the triangle ——— A B G. 65. 15.
secondly the line ——— F P. 6. 68. 0,82489.
multiplyed by the outward scarpe ——— ♌ P. 10. 1,00000.
produceth the area of the trapezium ——— ♌ P F Q. 66. 80. 1,82489.

The area of the square ——— n R S v. is. 100.
which doubled because there are two pyramides is ——— 200.

Also multiplying the inward scarpe ——— X u. 15. 1,17609.
by the inward scarpe ——— X y. 15. 1,17609.
produceth the area of the square ——— X u z y. 225. 2,35218.

And we found before the line ——— e d 10. 02. 1,00086.
which multiplyed by the scarpe ——— d L. 15. 1,17609.
produceth the area of ——— e e d L. 150. 30. 2,17695.
which doubled is twice ——— e e d L. 300. 60.

Lastly having found before the line ——— c a. 19. 55.
which multiplyed by the line ——— I c. 15.
produceth the area of twice ——— I c a. 293,25.

Thus then the area of ——— A B G. 65. 15.
the area of ——— ♌ P F Q 66. 80.
the area of twice ——— n R S v. 200.
the area of ——— X u z y. 225.
the area of twice ——— e e d L. 300. 60.
the area of twice ——— I c a. 293 25.
The summe of all these is ——— 1150. 80. 3,06100.
multiplyed by a third part of the altitude ——— 5. 0,69897.
produceth the solid content in feete of all these
pyramids in the corners ——— 5754. 3,75997.

Thus

Thus then the ſolid content of the Rampire
the ſcarpings excepted is ——— 391817. foote.
the ſolid content of the ſcarpings the
pyramids in the corners excepted is ——— 103472.
the ſolid content of the pyramids in
the angles or corners is ——— 5754.
the ſumme of all theſe is the ſolid content
of this part of the Rampire in cubicke feete ——— 501043.
which doubled is the ſolid content of one
bulworke and one curtaine namely ——— 1002086.
And this multiplyed by 6. becauſe this fort
hath 6. bulworkes ——— 6.
produceth the ſolid content of the whole
Rampire round about in cubicke feete ——— 6012516.

The Parapet of the Rampire.

And thus as we have found the ſolid content of the Rampire in cubicke feete, we may in like manner finde the content of the Parapet of the Rampire, if you will take that paines: But conſidering that the ſcarpings thereof within and without are very little, the height alſo not exceeding 6. foote; it may ſuffice if we finde the middle length of it by taking halfe the ſumme of the outward and inward perimeter, and that multiplyed in the area of the Section, or Profile of the Parapet will produce neere hand the ſolid content of the Parapet.

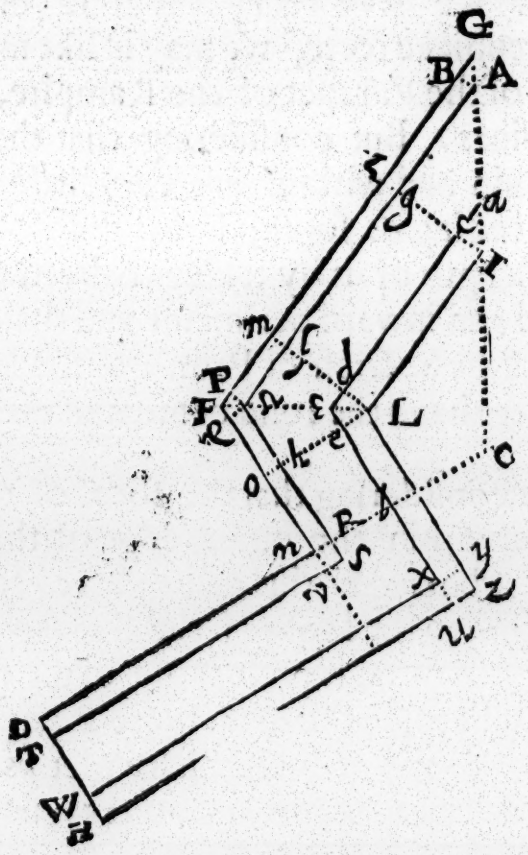
Firſt then conſidering that the foote of the Parapet is 10. foote within the outer edge of the Rampire, (the Rampire having in this example 10. foote ſcarpe, before it riſeth to the foote of the Parapet) therefore let the lines, *T S* ſ *A*. repreſent the outer foote of the Parapet, and becauſe the inner foote is parallell thereto, therefore (to avoyd multiplicity) let us ſuppoſe the inner foote of the Parapet to be repreſented by the

lines *H & L I*, and ſuppoſing the breadth of the Parapet *TH*, or *g I*. to bee 20. foote, we have before found.

The line ——— *A Ω*. 260. 29.
The line ——— *Ω S*. 114. 57.
The line ——— *S T*. 220. foote.

For the line L I. *and firſt for* A g.

As tangent halfe the flanked angle ——— *g A I*. 37. d. 36. t. c. 10, 11502.
to the breadth of the parapet ——— *I g*. 20. foote. 1, 30103.
ſo is *Radius* in proportion
to the line ——— *A g*. 26. 06. 1, 41605.



For

For f Ω.

As tang. halfe the angle of the ſhoulder — f Ω L. 56.d. 15'. t.e. 9,82489.
is the breadth of the parapet — f L. 20. foote. 1,30103.

ſo is *Radius* in proportion
to the line — f Ω. 13. 36. 1,12592.
whereto adding the line — A g. 26. 06.
the ſumme is — 39. 43.
which ſubſtracted from — A Ω. 260. 29.
remaines f g. being equall to — L l. 220. 86.

For the line L z.

Againe from the line — Ω S. 114. 57.
ſubſtracting Ω h. equall to — f Ω. 13. 36.
there remaines the line — h S. 101. 21.
whereto adding the thickneſſe of the parapet — 20.
the ſumme is the line — L z. 121. 21.

For H z.

And if to the line — S T. 220.
we adde the thickneſſe of the parapet — 20.
we have the line — H z. 240.

Thus then we have the lines about the outer foote of the parapet —
A Ω. 260. 29.
Ω S. 114. 57.
S T. 220. 00.

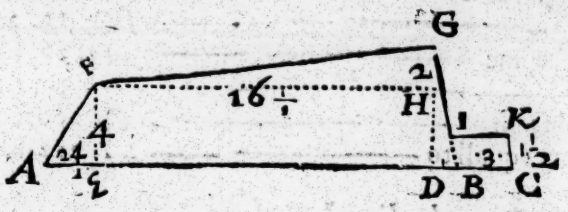
And alſo the lines about the inſide of the parapet —
L l. 220. 86.
L z. 121. 21.
H z. 240. 00.

The ſumme of them all is — 1176. 93.
the halfe whereof is — 588. 46.

Which is thē meane lēngth of the parapet from thē middle of the curtaine to the angular point of the bulworke.

Now for the area or ſuperficiall quantity of the Profile

file or Section of the Parapet, ſuppoſe it be as in this figure. Wherein let the foote of the parapet here repreſented by *A B.* be in breadth 20. foote, the breadth



of the banke or foote-pace within the parapet *B C.* 3. foote, the height of that banke 1 ⅓ foote, the height of the inner ſide of the Parapet *D G.* 6. foote. the height of the outer ſide *E F.* 4. foote, the outward ſcarpe *A E.* 2 ½ foote, the inward ſcarpe *D B.* 1 foote.

Then is the line F H. *or* ——— E D. 16. 5.
which multiplyed by the height D H. *or* —— F E. 4.
produceth the area of the long ſquare F E D H. 66. f. ſq.

Alſo the ſcarpe ——— A E. 2. 5.
multiplyed by halfe the height ⅓ —— F E. 2.
produceth the area of the triangle —— F A E. 5. f. ſq.

Thirdly the line ——— F H. 16. 5.
multiplyed by halfe the height ⅓ —— G H. 1.
produceth the area of the triangle —— F G H. 16. 5.

Fourthly the ſcarpe ——— D B. 1. foote.
multiplyed by halfe the height ⅓ —— G D. 3. foote.
produceth the area of the triangle —— G D B. 3. ſq. feet.

Laſtly

Lastly the breadth of the banke ——— BC. 3. foote
multiplyed by the height thereof ——— BI. 1. 5.
produceth the area of the romboydes — IKCB. 4. 5.

The summe of these five is the area of the
whole section in square feete — AFGIKC. 95. 1, 97772.
which multiplyed by the meane length of
the parapet ——— 588. 46. 2, 76972.
produceth in cubicke feete ——— 55904. 4, 74744.

Which is neere hand the solid content of the Parapet, from the middle of the curtaine to the angular point of the next bulworke.

Therefore being doubled it is the solid content of the Parapet for one curtaine and one bulwork. 111808.
And because this Fort hath 6. bulworkes
therefore if we multiply the same by ——— 6.
the product is in solid feete ——— 670848.

Which is (neere hand) the solid content of the Parapet of the Rampire round about the Fort.

If you desire the solid content of the Parapet more exactly, you may worke after the forme of the example before shewed, in casting up the content of the Rampire. And in like manner you may doe for the solide content of the Parapet of the Fausse bray, and of the counterscarpe or covert way, which forasmuch as they may bee easily conceived by these examples, wee passe them over and proceede to other things.

To finde what quantity of earth will serve to make the Rampire or Parapet, 100. foote long or more or lesse.

The area of the Section of the Parapet
we found before to be of square feete —— 95.
which multiplyed by the length given —— 100.
produceth in cubicke feete —— 9500.

And so much earth will serve to make the Parapet in length 100. foote.

And seeing the foote of the rampire is in breadth 70. foote.
and the upper part of it in breadth —— 45.
the summe of these is —— 115.
The halfe whereof is the meane breadth
of the Rampire namely —— $57\frac{1}{2}$.
which multiplyed by the height of the Rampire — 15.
produceth the area of the Section of the
Rampire in square feete —— $862\frac{1}{2}$.
which multiplyed by the length given —— 100.
the product in cubicke feete is —— 86250.

And so much earth serves to make the Rampire 100. foote long.

To finde what quantity of earth will raise the Rampire to any height assigned.

For brevity and perspicuity we will here as in other places, runne the example along with the rule, wherefore let it be required to finde what quantity of earth will

will raiſe thē Rampire 6. foote high, and 100. foote in length. And foraſmuch as the Rampire in riſing 15. foote, ſcarpes 25. foote, therefore in riſing 6. foote it will ſcarpe 10. foote.

Therefore as

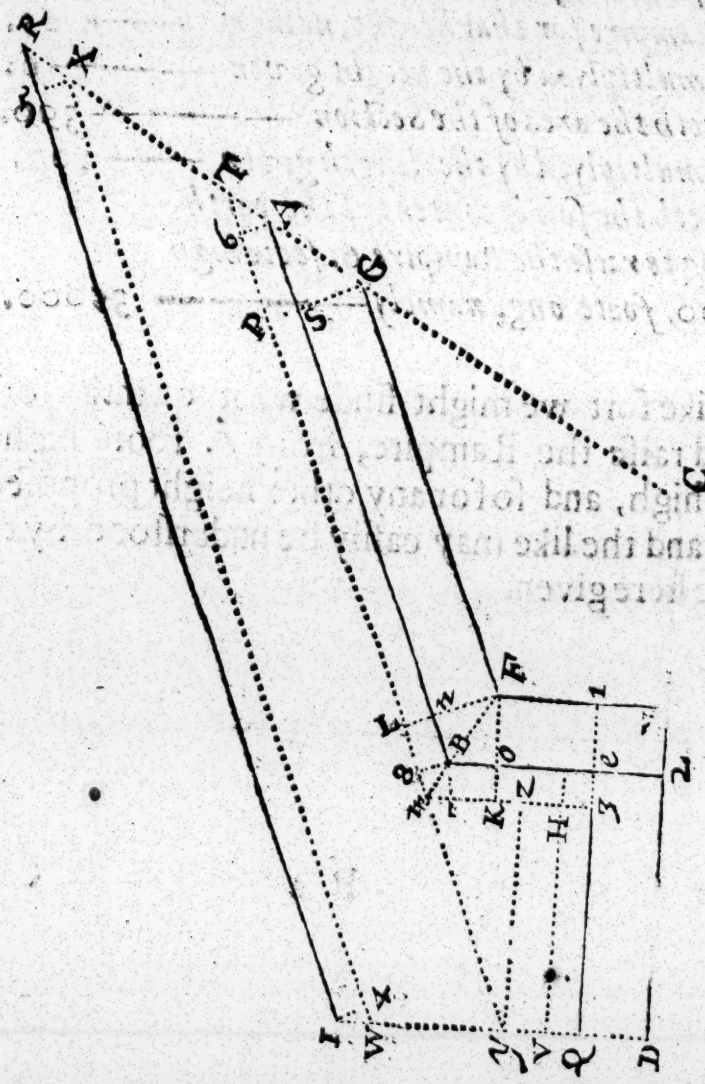
The breadth of the Rampire at the foote is —— 70. foote.
ſo being rayſed 6. foote, the breadth is —— 60.
the ſumme of theſe breadthes is —— 130.
the halfe whereof is the meane breadth of the Rampire for that height, namely —— 65.
which multiplyed by the height given —— 6.
produceth the area of the Section —— 390. f.ſq.
which multiplyed by the length given —— 100.
produceth the ſolide content of the earth ſerving to raiſe the Rampire 6. foote high and 100. *foote long, namely* —— 39000. cub.f.

In like ſort we might finde what quantity of ēarth would raiſe the Rampire, from 6. foote high to 12. foote high, and ſo for any other height propoſed, but theſe and the like may eaſily be underſtood by the example here given.

CHAP. X.

Of the Capacity or ſolide content of the Ditch, and in what time it may be digged.

THe ditch may be 140. foote broad, ſometimes more ſometimes leſſe, as occaſion requires: For if the ground be low, that it cannot bee



digged

digged deepe by reaſon of water, the ditch muſt bee the broader that there may be earth enough for the Rampire and Parapets, if the ditch be dry it muſt be the deeper, and have the leſſe ſcarpe. In this example wee make the breadth of the ditch at the toppe to be 120. foote, and at the bottome 100. foote, the depth 10. foote, and the ſcarping on either ſide 10. foote. Now then according to what wee have before ſayd, if there be a Fauſſebray and a Parapet thereto, the inner edge of the ditch, will be diſtant from the outter edge of the Rampire, 30. 40. or 50. foote according to the breadth of thoſe workes. Let it here be diſtant 40. foote, ſo that in this figure let *D N F G.* repreſent the outward foote of the Rampire, *Q e B A.* the inward ſide of the ditch, *I R.* the outſide of the ditch.

Now for finding the capacity of the ditch; firſt (as we did before for the ſolid content of the Rampire) we will finde the compaſſe of the ditch, on the outſide and on the inſide: ſecondly the perpendicular capacity of the ditch, according to the leaſt breadth of the ditch, which is at the bottome; thirdly the content of the ſcarpings, and laſtly of the pyramids in the angles.

Problem. I.

To finde the inward and outward compaſſe of the ditch.

THere is already knowne
The halfe curtaine —— *D N.* 210. *foote.*
the flanke —— *F N.* 111. 25.
the front —— *F G.* 280.

And there is required the compasse of the ditch on either side.

First for the outside of the ditch —— *1 R.* 649.5.
we found it before *Chap.* 8.

We come therefore to the inward side —— *Q e B A.*

For the line B A. *and first for* A S.

As tang. halfe the flanked angle —— *S A G.* 37. d. 30'. t. c. 10,11502.
to the distance of the ditch from the Rampire — *S G.* 40. foote. 1,60206.
so is *Radius* in proportion
to the line —— *A S.* 52,13. 1,71708.

Secondly for B *n.*

As tang. halfe the angle of the shoulder —— *n B F.* 56. d. 15. t. c. 9,82489.
to the ditch from the Rampire —— *n F.* 40. foote. 1,60206.
so is *Radius* in proportion
to the line —— *B n.* 26. 73. 1,42695.
whereto adding the line before found —— *A S.* 52. 13.
as also *n S.* equall to the front —— *F G.* 280.
the summe is the line —— *B A.* 358.86.

For the line B e.

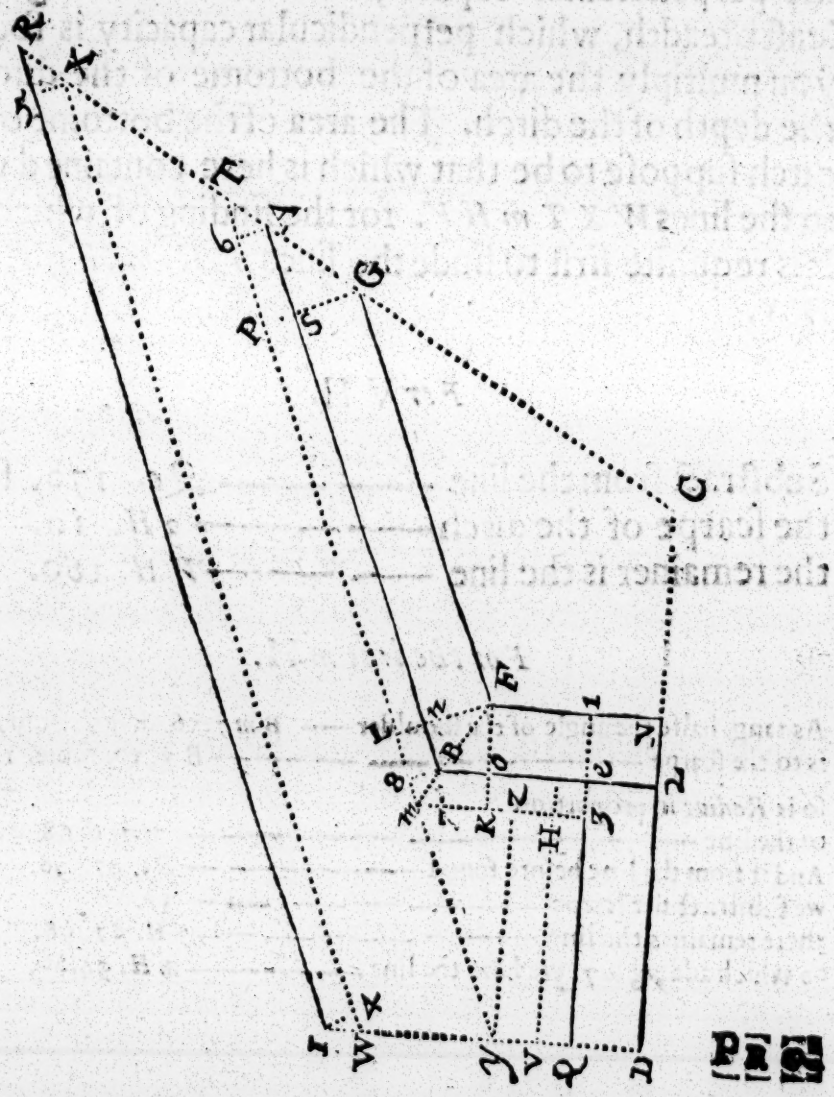
And if we substract from the flanke —— *F N.* 111. 25.
the distance of the ditch from the Rampire —— *1 e.* 40. foote.
there remaines *F 1.* being equall to —— *O e.* 71. 25.
whereto adding *B O.* which is equall to —— *B N.* 26. 73.
the summe is the line —— *B e.* 97 98.

For

For the line Qe.

Laſtly ſubſtracting from halfe the curtaine ——— D N. 210, foote.
the diſtance of the ditch from the Rampire ——— 2 N. 40.
there remaines D 2. equall to the line ——— Qe. 170.
whereto adding the line ——— Be. 97. 98.
and alſo the line ——— B A. 358.86.
the ſumme is the compaſſe ——— Qe B A. 626.84.

which is the twelfth part of the inward compaſſe of the ditch.



Problem. II.

To finde the perpendicular capacity of the ditch according to the least breadth thereof which is at the bottome, and first the lines thereto requisite.

BEcause the ditch is scarping and narrower at the bottome than at the toppe, you may first search the perpendicular capacity thereof according to its least breadth, which perpendicular capacity is found if you multiply the area of the bottome of the ditch by the depth of the ditch. The area of the bottome of the ditch suppose to be that which is here contained within the lines *W X T m H V.* for the finding of which area it is requisite first to finde the lines *V H. m H. y V. y T. W X.*

For V H.

Substract from the line —— —— *Qe.* 170. foote.
the scarpe of the ditch —— —— —— 3 *H.* 10.
the remainer is the line —— —— —— *V H.* 160.

For the line m H.

As tang. halfe the angle of the shoulder —— *B m* 7. 56. d. 15'. t.c 9,82489.
is to the scarpe —— —— —— —— —— —— *B* 7. 10. foote. 1,00000.

so is *Radius* in proportion
to the line —— —— —— —— —— —— —— *m* 7. 6 68. 0,82489.
And if from the line before found —— —— —— —— *B e.* 97. 98.
we substract the scarpe —— —— —— —— —— 3 *e.* 10.
there remaines the line —— —— —— —— —— 7 *H.* 87. 98.
to which adding *m* 7. we have the line —— —— —— *m H.* 94.66.

And

And seeing the angle of the shoulder is —— ∠ *m T*. 112. d. 36.
the compl. thereof to 180. deg. is the angle —— ∠ *m y*. 67. 30.

For y V. *and first for* m y.

As the sine of the angle —— ∠ *m y*. 67. d. 36. s. 0,03438.
to the line y ∠. being equall to —— *V H*. 160. foote. 2,20412.
so is *Radius* in proportion
to the line —— *m y*. 173. 18. 2,23850.

Secondly, for m z.

As the sine of the angle —— ∠ *m y*. 67. d. 36. s. 0,03438.
to the same line —— ∠ *y*. 160. foote. 2,20412.
so sine complement the angle —— ∠ *m y*. 67. d. 36. s.c. 9,58284.
to the line —— *m* ∠. 66. 27. 1,82134.
which substracted from the line —— *m H*. 94. 66.
there remaines ∠ *H*. equall to —— *y V*. 28. 39.

For the line y T. *and first in the triangle* 6 A T.

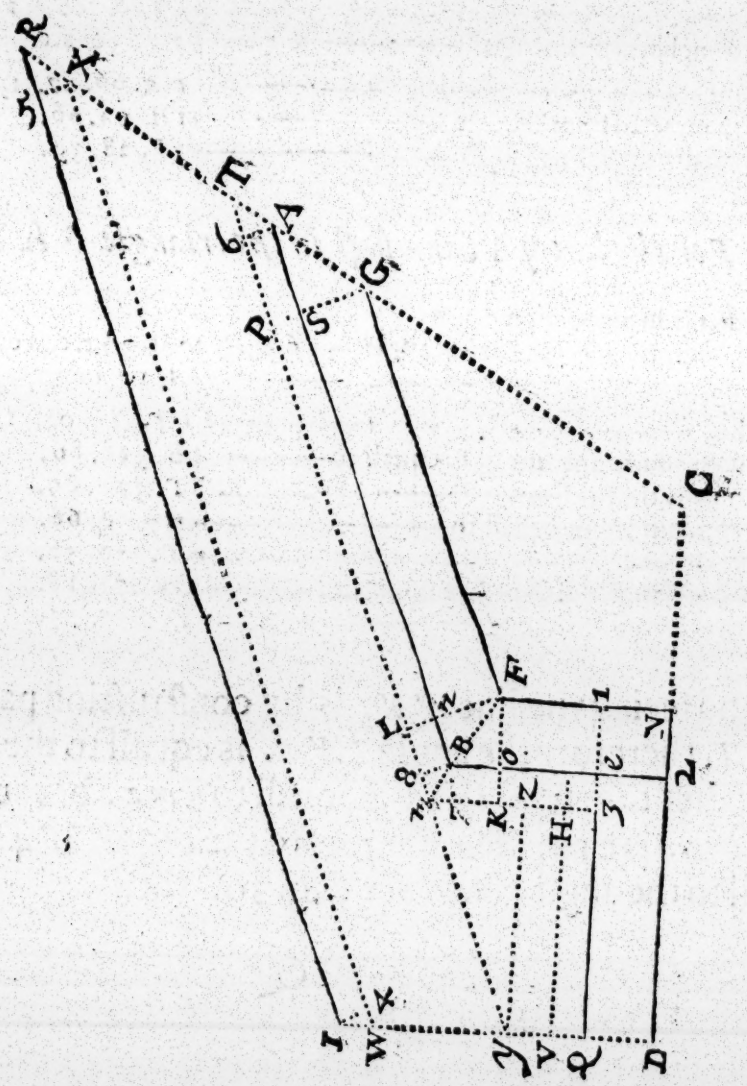
As *Radius* is in proportion
to tang. compl. halfe the flanked angle —— 6 *T A*. 37. d. 36. t. c. 10,11502.
so is the scarpe of the ditch —— 6 *A*. 10. foote. 1,00000.
to the line —— 6 *T*. 13. 03. 1,11502.
whereunto adding the line 6, 8. equall to —— *A B*. 358. 86.
the summe is the line —— 8 *T*. 371. 89.
whereto adding 8 *m*. equall to —— *m* 7. 6. 68.
we have the line —— *m T*. 378. 57.
to which adding the line before found —— *m y*. 173. 18.
we have the whole line —— *y T*. 551. 75.

And seeing the line *W X*. is by construction parallell to *y T*. therefore the angle *I W* 4. is equall to the angle *I y m*. but the angle *I y m*. is equall to *y m z*. because *I y*. and *m z*. are parallels, therefore the angle *I W* 4. is equall to the angle *z m y*. 67. deg. 36. then

For the line W X. I finde first W 4.

As the tangent of the angle ——— *I W* 4. 67. d. 36. t.c. 9,61722.
to the ſcarpe of the ditch ——— I 4. 10. foote. 1,00000.

ſo is *Radius* in proportion
to the line ——— 4 *W*. 4. 14. 0,61722.
And before we found 6 *T*. equall to ——— 5. *R*. 13. 03.
which ſubſtracted from the line ——— *I R*. 649.50.
there remaines *I* 5. equall to ——— 4 *X*. 636. 47.
whereto adding ——— 4 *W*. 4. 14.
the ſumme is the line ——— *W X*. 640. 61.



For

For the area of the bottome, and the perpendicular capacity.

To the line —— *W X.* 640. 61.
adding the line —— *YT.* 551. 75.
the ſumme is —— 1192. 36.
the halfe whereof is —— 596. 18.
which multiplyed by the breadth at the bottome —— 100. foote.
produceth the area of the figure —— *W X T y.* 59618. ſq. feete.

Againe.

we found before the line —— *m H.* 94. 66.
and the line —— *y V.* 28. 39.
the ſumme of them is —— 123. 05.
the halfe whereof is —— 61. 52½. 1,78906.
which multiplyed by —— *V H.* 160. 2,20412.
produceth the area of the trapezium —— *m y V H.* 9844. 3,99318.
whereunto adding the area of —— *W X T y.* 59618.
the ſumme is the area of the bottome of the ditch —— *V W X T m H.* 69462. ſq. feete.
which multiplyed by the depth —— 10. foote.
produceth the perpendicular capacity of the ditch, or the ſolide content of the ditch, the ſcarpings excepted, namely —— 694620. cub. feete.

For the Scarpings.

The length of the ſcarpings, namely of
the line — *V H.* 160. foote.
the line — *H 7.* 87. 98.
the line 8,6. — 358. 86.
the line — 4 *X.* 636. 47.
the ſumme of theſe 4 lines is —— 1243. 31.
which multiplyed by the ſcarpe —— 10.
produceth the area —— 12433. 1.
the halfe whereof is —— 6216. 5.
which multiplyed by the d pth —— 10.
produceth the ſolid content of the ſcarpings, the pyramids in the corners excepted, namely —— 62165. cub. feete.

For the Pyramides in the corners.

The line ——— 3 e. 10. foote.
which multiplyed by the ſcarpe ——— 3 H. 10. foote.
produceth the area of the ſquare ——— 3 e ϒ H. 100. foote ſq.

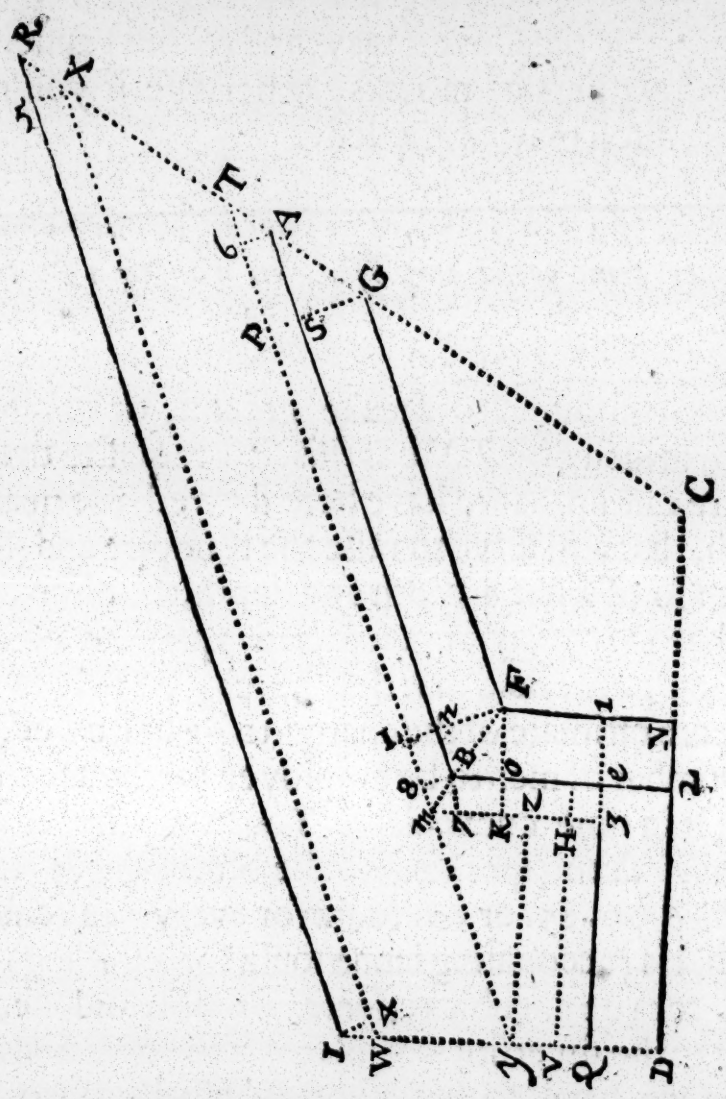
For the Trapezium. 7 B 8 m.

The line ——— 7 m. 6. 68.
multiplyed by the ſcarpe ——— 7 B. 10.
produceth the area of the baſe ——— 7 B 8 m. 66. 80.
which doubled becauſe there are two pyramides is ——— 133. 60.

Alſo the line ——— 6 T. 13. 03.
multiplyed by the ſcarpe ——— A 6. 10.
produceth twice the area of ——— A 6 T. 130. 30.
the halfe whereof is the area of ——— X 5 R. 65. 15.

The line ——— 4 W. 4. 14.
multiplyed by the ſcarpe ——— 4 l. 10.
produceth twice the area of ——— W 4 l. 41. 40.

Thus then the area of ——— 3 e ϒ H. is. 100. foote.
the double area of ——— 7 B 8 m. is. 133. 60.
the double area of ——— A 6 T. is. 130. 30.
the area of ——— X 5 R. is. 65. 15.
the area of ——— W 4 l. is. 41. 40.
the ſumme of all thoſe area is ——— 470. 45.
which multiplyed by the depth ——— 10. f.
the product is ——— 4704. 50.
the third part whereof is the ſolide content
of theſe pyramides ——— 1568. 17.
Thus then the perpendicular capacity of
the ditch, the ſcarpings excepted is ——— 694620.
The ſcarpings of the ditch, the pyramides
in the corners excepted is ——— 62165.
The ſayd pyramids in the corners ——— 1568.
So the whole capacity of this part of the ditch is ——— 758353.
Which doubled is the ſolide content of the ditch,
for one bulworke and one curtaine ——— 1516706.
And becauſe this Fort hath ſixe bulworkes
therefore multiplying by ——— 6.
we have the ſolide content of the ditch round
about this Fort in cubicke feete ——— 9100236.



But before we found the ſolide content of the
Rampire to be ——— 6012516
And the ſolid content of the Parapet on
The Rampire to be ——— 670848.
So that the ſolide content of the Rampire
and its parapet is ——— 6683364.
which ſubſtracted from the ſolide content of
the ditch there remaines ——— 2416872.

Which earth rēmaining may be ēmployed to make the Parapet of the Covert way, and of the Fauſſebray, and for Cavalliers or mounts, otherwiſe if you make none, the ditch may be the leſſe.

To eſtimate the charge to be beſtowed, or the number of men, or time to be employed, in raiſing a Fort propoſed.

BEfore you begin to breake ground, or to ēmploy men in ſuch a buſineſſe as this, it is requiſite that the Enginere caſt up, as we have here ſhewed, the quantity of earth, that will ſerve to raiſe the Rampire and Parapets, and ſo of what breadth and dēpth, the ditch ought to be, that there may be a ſufficient quantity of earth for that purpoſe: and that thus he may be able to give ſome neere eſtimate of the charge to be beſtowed, and of the number of men to be employed for the accompliſhing of it in time convenient. Touching the charge, S. *Marolois* ſaith (ſpeaking of the Netherlands) that it is about 16. 20. 25. or 30. ſoulz for every 144. cubicke feete, that is (accounting tenne ſoulz for a ſhilling) 14ˢ. or 20ˢ. for 1000. cubicke feete, or more or leſſe, according to the diverſities of places and occaſions. In *England* we have no ſuch workes uſually done, and therefore we cannot ſpeake of any ordinary price, neither can there be any generall rule given for the time or number of men to be employed, in regard of the great diverſity of grounds to be fortified, and other conſiderations, it may therefore ſuffice to ſhew how ſomē neere eſtimate may be given.

As to give an eſtimate in what time a certaine number

of

of mēn may digg the aforesayd ditch, containing 9100236. cubicke feete, of earth, it is requisite first to know what one man will digge in a day. When I was in the Fennes in *Lincolneshire*, I was informed by men of good experience there, that a man would digge and fill into a wheele-barrow in a day, 17. foote square of earth, and about 27. inches deepe, which is 650. cubicke feete of earth; I have beene enformed the like in other places, where they have wrought in Marsh land: S. *Marolois* in his booke of Fortification affirmes, that according to some of the best experienced in the Netherlands, a man working his best in earth that is fat and fast, may digge and fill into a wheele-barrow in a day 648. cubicke feete. But it may be, in any of these places, when they doe so much, besides the aptnesse of the earth, they take extraordinary paines. Let us therefore suppose that the most a man can ordinarily digge, and fill into a wheele-barrow of good earth, to be 500. cubicke feete in a day; then may 200. men digge, 100000. feete in a day, so that according to this account, 200. men may digge and fill away the foresayd ditch containing 9100236. cubicke feete in 91. dayes or thereabouts, for dividing 9100236. by 100000. the quotient 91. dayes and somewhat more not to be regarded. But if you finde the earth to be such, that a man cannot with ordinary paines taking, digge 500. foote in a day, you must make your account accordingly; as suppose I finde that a man digges but 300. foote in a day, and I would know in what time they would digge the foresayd ditch, I say then by the rule of proportion.

As

As 1. *Mⁿ.*
digges 300. foote —— 2,47712.
so may 200. *Men.* —— 2,30103.
digge 60000. foote —— 4,77815.

Againe.

As 60000. foote —— *co. ar.* 5,22186.
is to 1. dayes worke.
so 91000236. foote. —— 6,95993.
is 152. dayes worke almost. —— 2,18179.

Otherwise you may say by the rule of three reversed.

If —— 500. foote a day.
require —— 91. dayes.
then —— 300. foote a day.
require —— 152. dayes worke almost.

In like sort you may estimate in what time any other number of men will be able to doe it, especially after some tryall made, for by reason of the great diversity of grounds, and other occurrents, this point cannot be alwayes determined without some tryall. Besides men doe usually much more when they take a businesse by the great (as they terme it) then when they worke by the day. Now looke how many Pyoners you employ to digge, so many you had neede to have with wheele-barrowes to carry it to the Rampire and Parapets, and others there to spread it, tread it, and lay it even, and to rayse the worke in its due forme, and this being diversly performed, sometimes with a face of turfe, sometimes

of

of earth sowne with grasse seede, sometimes laying faggots or wood in the Rampire; sometimes none, sometimes a foundation to be layd (as in soft Oazie grounds) of timber or brick-worke &c. there is no generall rule to be prescribed in this point, touching the certaine number of men to be employed.

CHAP. XI.

Of such other workes as are sometimes made in or about Forts of most importance.

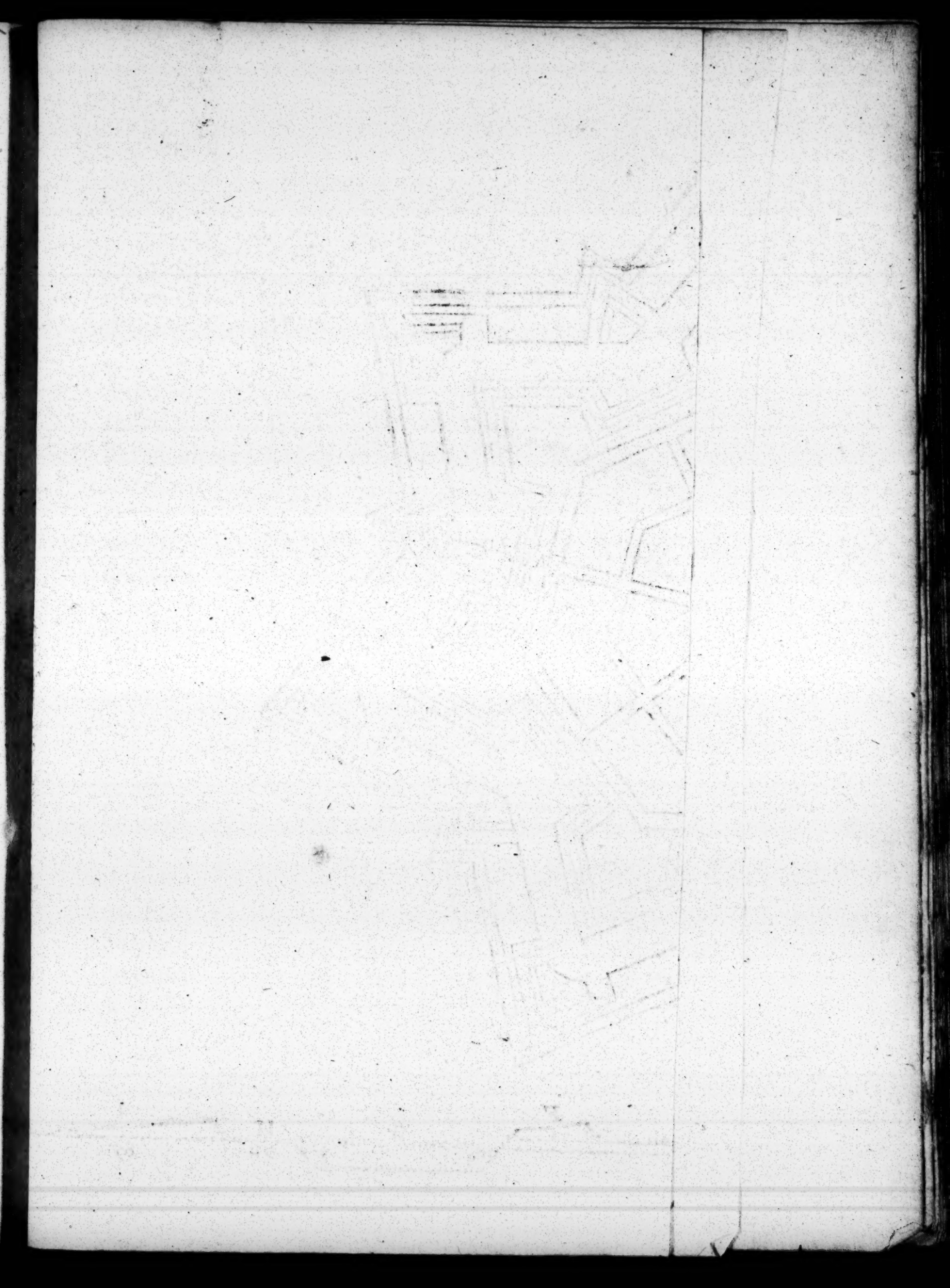
WHen I began this Treatise I had no intent to have waded so farre in this part of Architecture military, as I have already done, but onely to shew therein the application of the Doctrine of plaine triangles, as it is performed by this late invention of Logarithmes, and indeede that had beene sufficient to those that have reade such moderne Authors, as have more fully handled this subject in other Languages. But considering how little hath beene written hereof in our *English* tongue, and that the practise of it with us is very rare. I have beene somewhat larger than I intended, and here further have annexed this description of a Fort of seven sides, expressing therein such other workes as are sometimes made in or about the most compleate Forts that are usually reared.

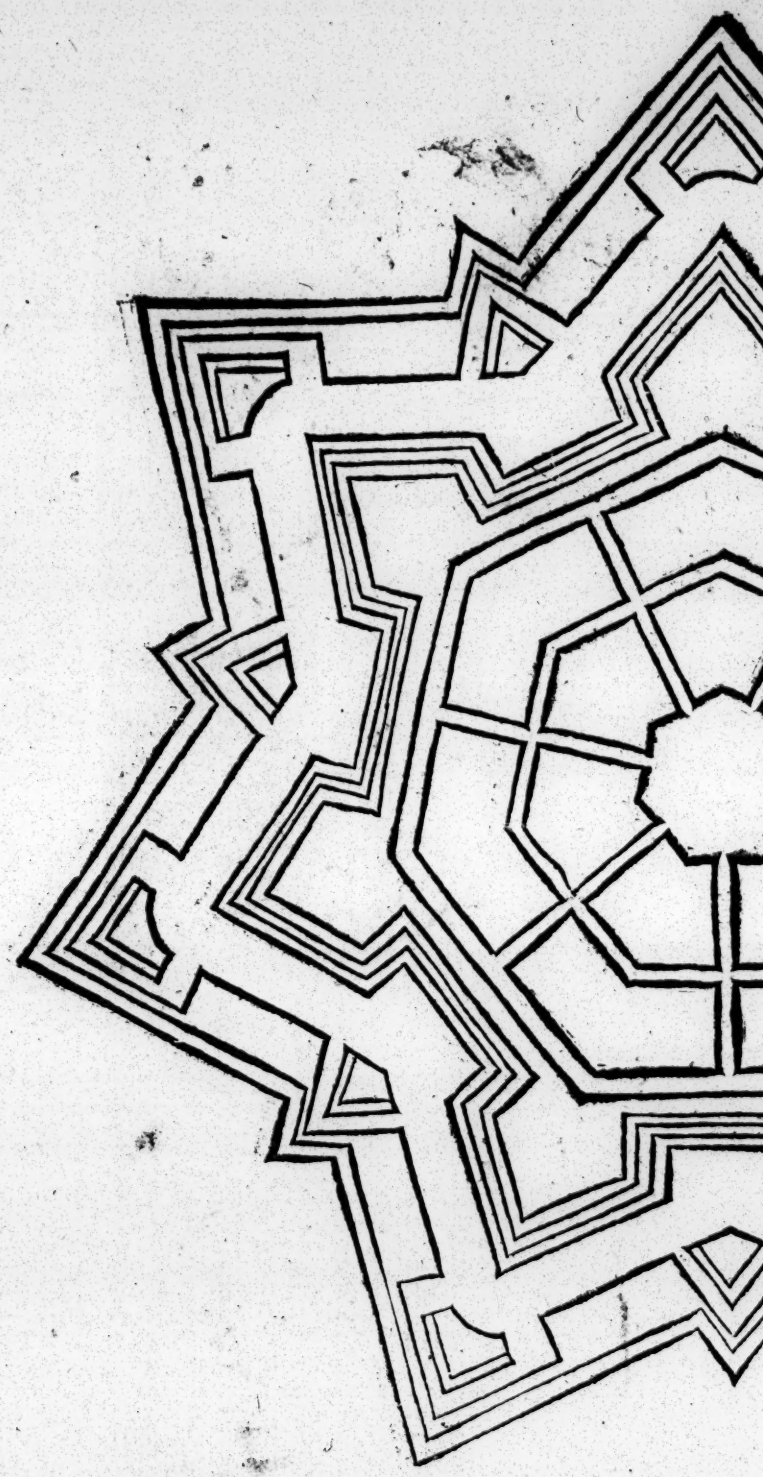
We have before sufficiently spoken of the Rampire and its Parapet, here marked with *A.* as also of the walke for the Rounds or Fausse-bray *B.* and of the Parapet

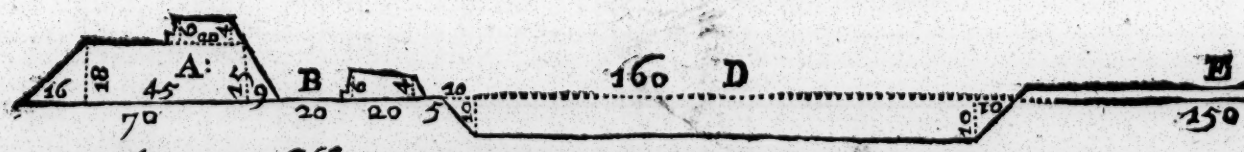
rapēt thēreof *C.* as alſo of the ditch, here marked with *D.* and of the curtaines, bulworkes, fronts, flankes, ſcarpings, &c. to proceede therefore to the reſt. Next within the Rampire, betweene the Rampire and the houſes, there is a ſtreete left ſometimes 30. but here 40. foote broad, whereto the ſouldiers may retreate, or bē put in array as occaſion requires, the other ſtreets are ſometimes 24. but here 30. foote broad, and in the middle is the market place, being of the ſame forme whereof the Fort is, namely of ſeven ſides, every ſide being 15. or 18. rods, the other ſpaces betweene the ſtreetes, are for the houſes of the inhabitants and ſouldiers.

On the outſide of the ditch, betweene evēry two bulworkes, and againſt the middle of the curtaine is placed a Ravelin, ōne of them being marked with *E.* and the reſt ſcituated in like manner, the two Fronts of every of theſe Ravelins may be 15. 20. or 25. rods, and theſe are ſo madē on the edge of the ditch, that their inward angles are at the concourſe of the lines bounding the ditch; and that the Fronts of theſe Ravelins, might be the better defended, their outward angles are the more acute, inſomuch that they are flanked from all or the greateſt part of the Fronts of the bulworkes next unto them.

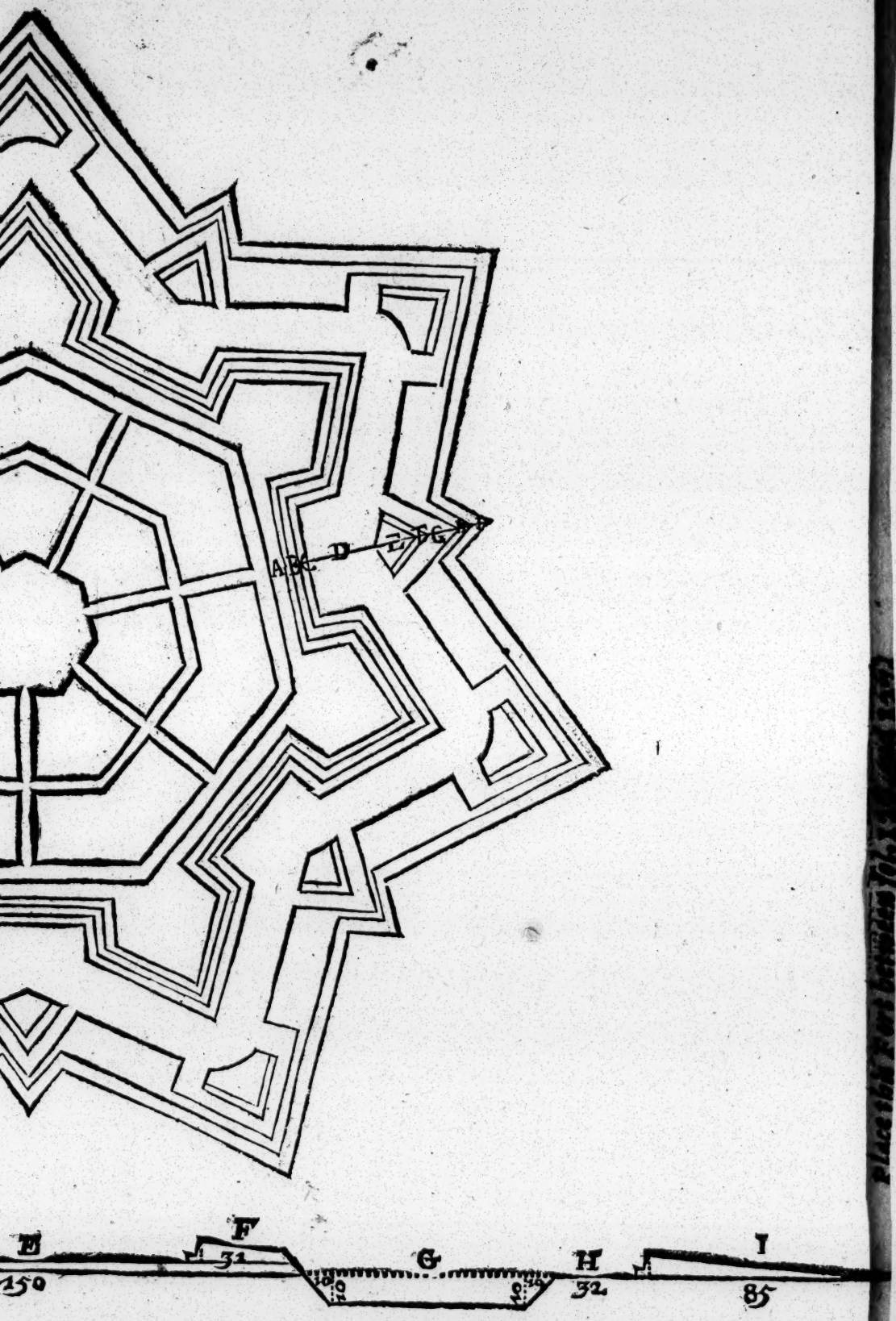
The Ravelin here marked with *E.* and ſo the reſt are raiſed above the champion (or levell whereon the Fort ſtands) 4. foote, and it ought not to be higher that it may not impeach the diſcovery of the champion about. And upon the Fronts of every of theſe Ravelins thus raiſed, you may make a Parapet 20. foote thicke, and 6. foote high, that ſo it may be Cannon proofe.







The *Profill or Section.*



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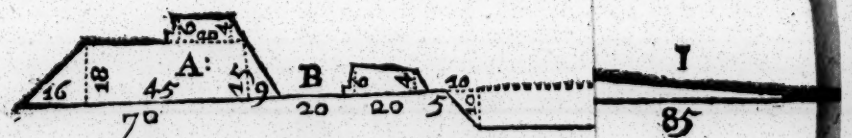


The Profill or Section

proofe. The ditch betweene the Ravelin and the counterscarpe, may be 5. or 6. rods broad, and as deepe as you can conveniently make it.

Ravelins thus made against the middle of the curtaine are very frequent in many Forts, being of good use to defend the fronts of the bulworkes; but the other Ravelins or halfe moones opposite to the angular points of every bulworke are not so usuall, notwithstanding, they also are sometimes made, and may be raised and have their Parapets, and ditch as the other, being also flanked by those Ravelins, that are against the curtaines. And without all these is the counterscarpe with a covert way, and an Argin or Parapet, which is inwardly 6. foote high, as hath beene before described, and as by this description, and the Section or Profile thereof may appeare, there is sometimes without the Parapet of the covert way a watred ditch, to impeach any suddaine assault of the enemy. The height, depth and breadth or thickenesse of all these workes are expressed in the sayd Section, wherein the height of the Rampire is 15. foote, and according to the judgement of some should not be more, if the Fort be made in a champion or plaine, where there are no hills neere unto it, but in case there be on any side higher ground that doth command the Fort, then must the Rampire on that side be raised higher, that the Fort may be the better covered and preserved thereby, from the annoyances that may be done against it from that place. And much after the forme here described is *Coverden* in *Friezland* fortified, having 7. bulworkes with Ravelins and halfe moones, &c. as in the figure being the most Royall regular Fort in the Netherlands.

There are also oft times in Forts, Cavaliers, Mounts, Platformes, or batteries, raised higher than any of the foresayd workes, aswell to discover the Country about, as to annoy an enemy, these are sometimes raised upon the bulworkes, if there be roome enough besides to use the flankes, but if the Gorge be too small, they may be raised on the curtaine, a little within the Rampire, so as the walke on the Rampire be not impeached by them.

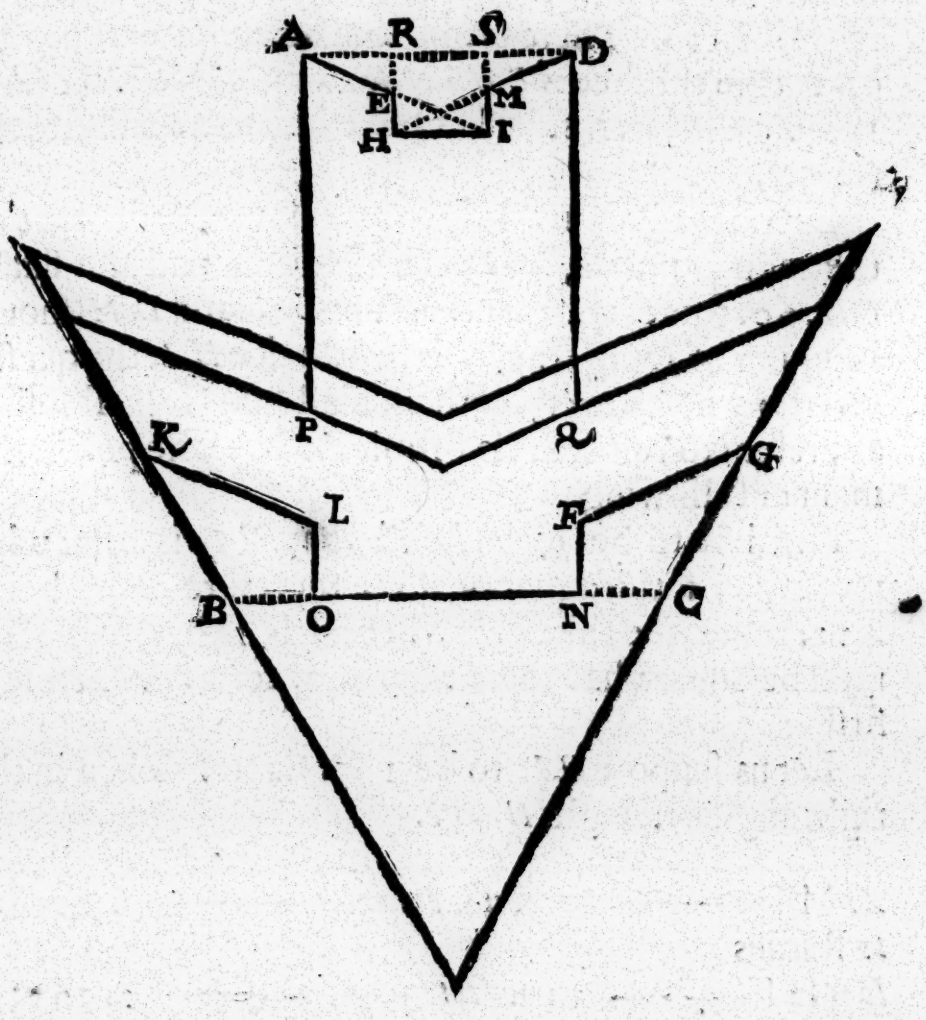
Of Horne-workes.

BEsides all these, and without all the workes before mentioned, there are sometimes made Horne-workes, yet I have seldome seene of them, but where an enemy is shortly expected. I was at *Breda* in *May An.* 1623. being that Summer wherein it was taken by the *Spaniard*, and then there was (as I remember) five of these Horne-works: others of them I saw at that time at *Bergen-op-som*, which was beseiged the summer before; these are sometimes made against the bulworkes, but more conveniently betweene the bulworkes, and against the curtaine, in forme as followeth.

Let *O N.* be the curtaine of a Fort, *O L.* and *F N.* the flankes *F G.* and *L K.* the fronts, *P Q.* the outside of the ditch, and let the outer foote of the Horne-worke be *P A D Q.* and the distance of the angular points thereof namely *A.* and *D.* from the shoulders of the bulworke *L.* and *F.* be equall to the line of defence *O G.* namely about 72. rods, and let the distance of those angular points *A.* and *D.* be equall to the curtaine of the Fort *O N.* so as the side of the Horneworke *D Q.* may

be

be in a right line with the flanke *F N.* and *A P.* with *L O.* (ſome would have the diſtance of theſe points *A.* and *D.* and ſo of *P.* and *Q.* to be leſſe than the curtaine by 4 or 5. rods, wherein you may doe as you like beſt) betweene the angular points *A.* and *D.* are formed as it were two halfe bulworkes, *A E H.* and *D M I.* their fronts being *A E.*



S and

and *D M.* their flankes *E H.* and *M I.* and the curtaine betweene them *H I.* Without this horneworke, that is without the line *P A E H I M D Q.* must be a ditch about 3. rods broad, and 6. foote deepe if the ground be low, otherwise the deeper the better, and within the same line may be a Rampire and Parapet, or onely a Parapet round about 6. foote high and 25. or 30. foote thicke more or lesse as occasion requires; without the ditch I have also seene a covert way and a Parapet thereto. These Horneworkes are sometimes cut off within the face *A E H I M D.* with another like face, namely with fronts, flankes and curtaines parallell to the former.

But now admit in this figure we have the distance of the angular points, *A D.* 420. foote, and the flanke *E H.* 60. foote, and that the fronts *A E.* and *D M.* should be either of them equall to the curtaine *H I.* the question is how much every of them must be. It shall suffice at present to resolve this Probleme by false position in manner following.

First it is to be understood that *H I.* is somewhat more than a third part of *A D.* therefore *A D.* being 420. foote, the third part whereof is 140. the line *H I.* must be somewhat more then 140. feete. Wherefore first

Let us suppose *H I.* to be 147. feete. Then in the right angled triangle *H M I.*

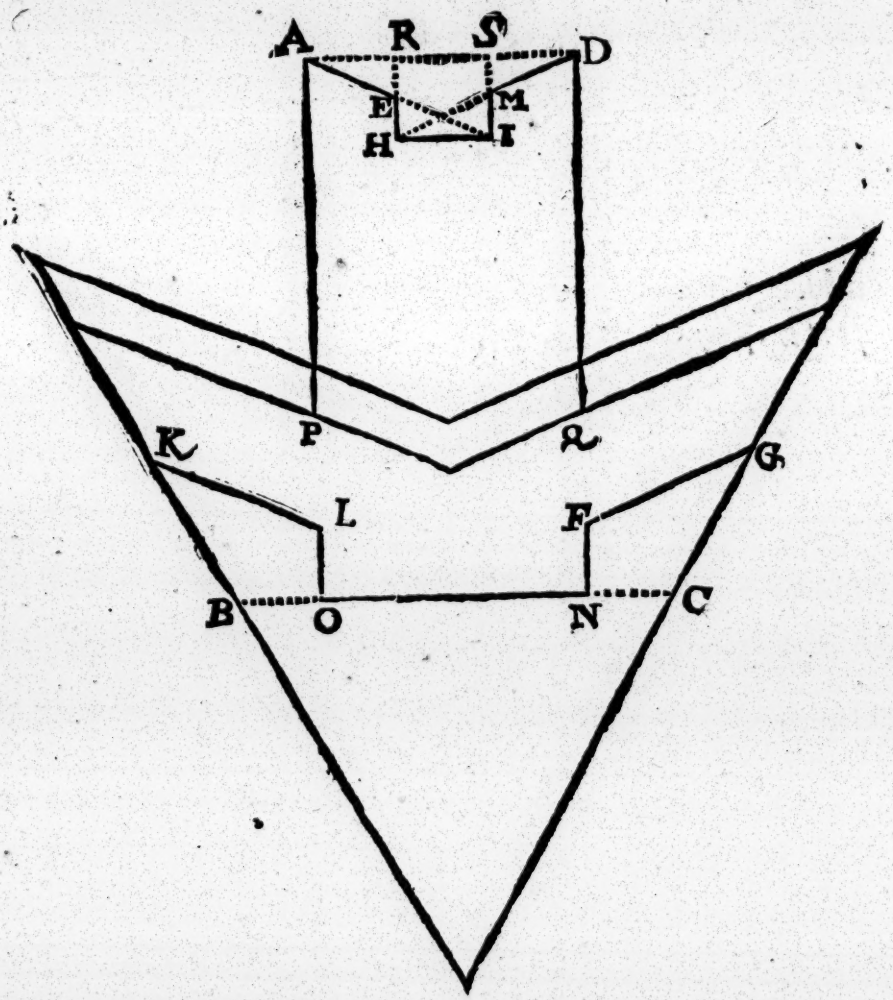
As M I	60. *feete. co. ar.*	8,22185.
to Radius		
so is H I	147. *feete*	2, 16732.
to tang. H M I.	67. d. 47'. 47''. ½.	10,38917.

where-

whereto is equall the angle — *S M D.* 67.d. 47'. 47'' $\frac{1}{2}$.

Againe.

As Radius
to M D —— 147 *feete* —— 2,16732.
so s. —— *S M D.* 67.d. 47'. 47'' $\frac{1}{2}$. —— 9,96654.
to —— *S D.* 136. 1. —— 2,13386.
and adding A R. —— 136. 1.
and R S. —— 147.
Summe is A D. —— 419. 2.
which ought to have beene —— 420.
so it is too little by —— $\frac{2}{10}$.



 There-

Therefore I suppose againe that *HI.* is 148. and then

As M I —— 60. feete. *co. ar.* 8,22185.
to Radius
so is H I. —— 148. feete. —— 2,17026.
to.t. H M I. 67. d. 56'. feete. —— 10,39211.

Whereunto is equall the angle *S M D.* 67. d. 56. *fere.*

As Radius
to M D. —— 148. *feete.* —— 2,17026.
so. s. S M D. 67. d. 56'. *fere* —— 9,96696.
to S D —— 137. 16. —— 2,13722.
And adding A R. 137. 16.
Also — R S. 148.
summe is A D. 422. 32.
which should be 420.
so it is + *by* —— 2. 32.

147 = $0\frac{3}{10}$

148 + $2\frac{32}{100}$

296 — 34104

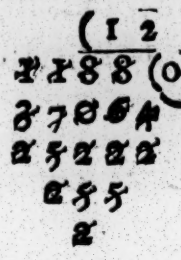
10 — 100

summe — 37064

100

summe of *er.* — 252

100



147 $\frac{120}{233}$ or 147 $\frac{1}{2}$ fere.

Thus having found *H I.* to be 147 $\frac{4}{10}$ we may more eafily finde the reſt ſaying,

As M I.	60. *ſcete. co. ar.*	8,22185.
to Radius		
ſo is	H I. 147. 4.	2,16850.
to tang.	H M I. 67. d. 51.	10,39035.

Whereunto is equall the angle *S M D.* 67. dēg. 51'. as alſo the angle *M D Q.*

As Radius		
to	M D. 147. 4.	2,16850.
ſo. s. c.	S M D. s. 22. d. 09.	9,57638.
to	M S. 55. 57.	1,74488.
whereto adding	M I. 60.	
ſumme is	S I. 115. 57.	

As Radius		
to	M D. 147. 4.	2,16840.
ſo s.	S M D. 67. 51.	9,96670.
to	S D. 136. 4.	2,13510.
which doubled is	272. 8.	
and adding	R S. 147. 4.	
ſumme is	420. 2.	

Which is more by $\frac{3}{10}$ of a foote than it ſhould bee by not taking the foregoing fractions exactly, which you may correct if you pleaſe.

CHAP. XII.

Of ſmall Forts or Field Skonces, and marking them out Mechanically, and firſt of a Skonce of foure ſides.

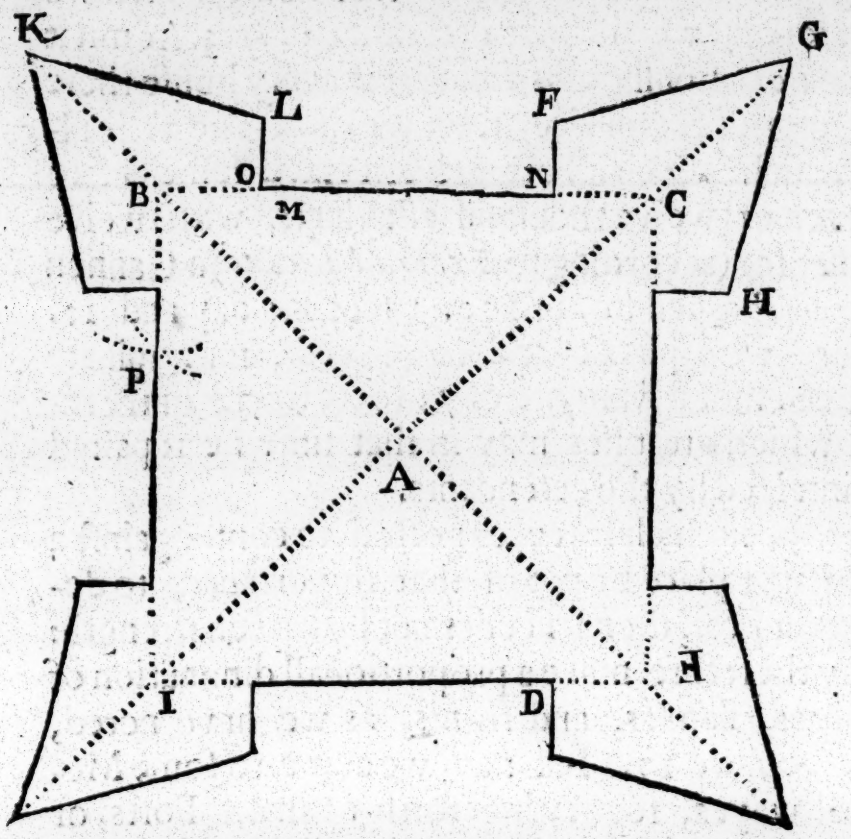
THus have I ſhewed at large the application of the *Doctrine of Plaine Triangles* by Logarithmes, in this part of *Architecture Military*, which was the onely thing I intended when I began this Treatiſe. But for the fuller underſtanding thereof I have (as occaſion required) handled other things incident; And now having ſpent more time herein then at firſt I aſſigned for it, and my other occaſions calling me away, I might have liberty here to conclude: yet conſidering that theſe Forts before mentioned are workes of ſuch labour induſtry and expence, that they may ſeeme hard to be accompliſhed, eſpecially to us, where they are not uſuall. I have thought it requiſite to ſhew, ſome mechanicall and eaſie way for delineating and ſetting forth of ſmall Forts or field Skonces: For though it was meete to ſhew the application in ſuch Royall Forts, as we have before ſpoken of; yet theſe being more eaſily made are more frequent, and have alſo their neceſſary uſes as well as the former. For it is to be underſtood that the Fort wherein we have before given an example conſiſting of 6. bulworkes, is ſufficient to containe 600. or 700.

700. houſhoulds more or leſſe, according to the quantity of ground that you aſſigne for each houſe, which we have before ſhewed how to determine *Chap.* 3. Admit it containe 600. houſhoulds, and that in every houſe there are two men fit for ſervice, then are there 1200. ſouldiers, which in ſuch a Fort are eſteemed ſufficient to oppoſe ten or twelve thouſand aſſaylants, with twelve Cannons, for (according to *Errard Barleduc*) a Cannon may be diſcharged 80. or 100. times in a day and 12. Cannons, well placed and employed, may ruinate with 1200. ſhot a Rampire of 72 foote thicke, or thereabouts, which breaches may in that time be repaired and maintained by the defendants.

If there be no ſuch force expected to come againſt a Fort, or if the place be not of that importance, to deſerue ſuch a Fort, then it needes not be of ſuch ſtrength: you may therefore make a proportionall diminution of the Gorges, flankes, and fronts, as we have noted, *Chap.* 2. *Axiome* 17. But now we come to ſome Mechanicall wayes, for ſetting forth of ſmall Forts, or field Skonces, and ſome ſuch we have before briefely touched, at the end of the ſixth chapter, others I will here ſhew, and firſt begin with a regular Skonce of foure ſides, which are moſt frequent.

Let *B C.* be the ſide of a ſquare to be fortified, and let it be required to ſet out the ſquare and the bulworkes thereof.

Firſt for ſetting out the ſquare, ſet a ſtake at *B.* and alſo at *C.* and having as is aforeſayd a chaine of 5. rods, or 50. feete, meaſure from *B.* towards *C.* 3. rods, which ſuppoſe to end at *M.* and there make a marke, alſo meaſure from *B.* ſquare off, as you gueſſe towards *I.* 4. rods,



rods, and keeping the end at *B.* fixed, turne about that end, or that part of your chaine which is at *P.* that with a ſharpe ſticke or iron point, you may deſcribe an Arch on the ground; then let one carry the end of your chaine which was fixed at *B.* unto the marke you made at *M.* and meaſure from *M.* to *P.* the whole length of your chaine 5. rods. marking in what part of the arch before made your chaine doth reach unto which ſuppoſe to be at *P.* and there ſet a ſtake.

Now ſuppoſe the ſide of your ſquare *BC.* to be 12. rods, then meaſure alſo from *B.* to *I.* 12. rods ſetting a ſtake

ſtakē at *I.* ſo as theſe three ſtakes *B P I.* may be a right line, and thus you have two ſides of your Fort *B C.* and *B I.* with the right angle at *B.* the like you may doe for the other angles at *I E.* and *C.* and for the ſides *I E.* and *E C.* and ſo the one will examine the other: Or otherwiſe meaſure from the ſtake at *I.* ſquare off, as you gueſſe towards *E.* 12. rods, likewiſe from *C.* towards *E.* 12. rods, and where theſe two meaſures meete in one as at *E.* there drive a ſtake, and ſo is the ſquare ſet out.

Now for the center of this ſquare, let one man ſtand at *B.* and another at *C.* and let a third man drive a ſtake ſo at *A.* that the man at *B.* may ſee it, in a right line towards *E.* and the man at *C.* may ſee it in a right line towards *I.* and ſo is the ſtake at *A.* the center or middle of the Fort.

Next for the bulworkes, divide the ſide of the ſquarē *B C.* into 5. equall parts, and make the Gorge lines *B O.* and *N C.* either of them one of thoſe parts, and ſo all the other Gorge lines alſo, make the head line *B K.* as much as two of thoſe parts, driving a ſtake at *K.* ſo as you may thence ſee the ſtake at *B.* and that at *A.* or *E.* all in a ſtreight line, the like doe for the angular points of the other three bulworkes. Then divide the Curtaine *O N.* into foure equall parts, and make the flanke *O L.* and ſo *N F.* and all the other flankes, to be one of thoſe parts; but for ſetting thoſe flankes ſquare off from the curtaines, you may drive a ſtake, ſo at the ſhoulder *F.* that you may ſee from thence the ſtakes at *N.* and *D.* all three in a right line, and the like is to be underſtood of all the other flankes. And thus are the curtaines, together with the flankes and fronts of the bulworkes ſet out.

Now ſuppoſing the ſide of the ſquare *B C.* to be 12. rods or 120. feete, then is the Gorgeline *N C.* 24. feete, the head-line *C G.* 48. feete, the curtaine *O N.* 72. feete, and the flanke *F N.* being a fourth part of the curtaine is 18 feete.

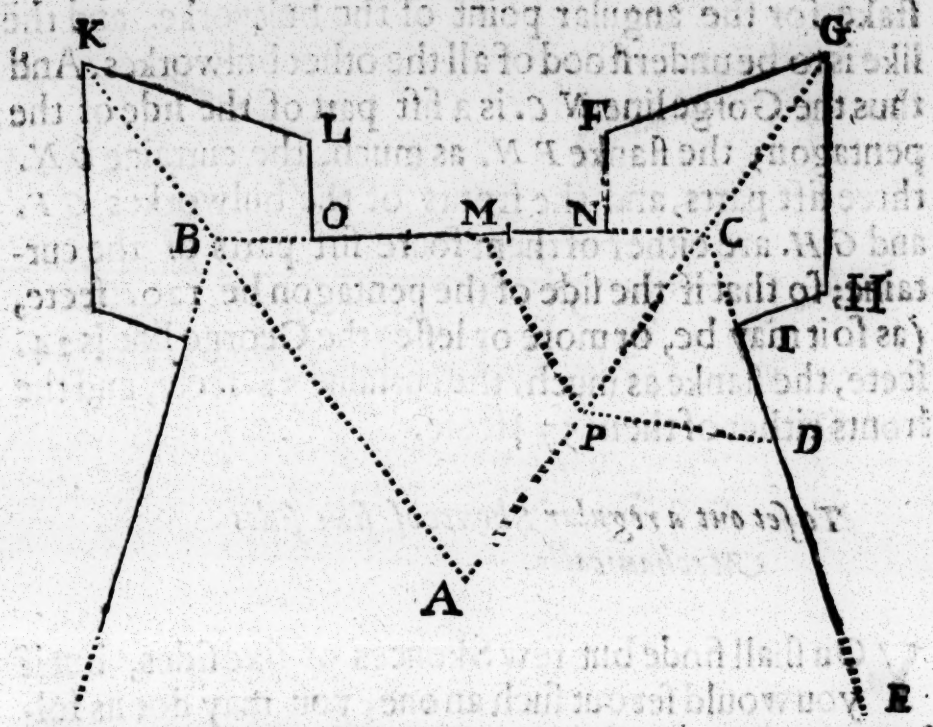
Otherwiſe having ſet out as before, the curtaines and Gorge-lines, and the angular points of the bulworkes, as *K.* and *G.* and ſtakes being ſet at the ends of every curtaine, as at *O.* let one drive a ſtake at *F.* ſo as one ſtanding at *G.* may ſee it to bee in a right line with the ſtake at *O.* and he that ſtands at *F.* may ſee it to be in a ſtreight line with the ſtake *N.* and *D.* ſo ſhall the ſtake at *F.* be the ſhoulder of that bulworke, and in like ſort may all the other ſhoulders of the bulworkes be ſet out, and conſequently all the flankes and fronts.

And thus having deſcribed at large, the ſtaking out of theſe Skonces of foure ſides, which are moſt uſuall, we ſhall be briefer in the reſt that follow.

To ſet out Mechanically a Regular Skonce of five ſides.

LEt *B C.* be one ſide of a Pentagon, firſt then to ſet out the other ſides Mechanically; having ſet a ſtake at *B.* and another at *C.* meaſure from *C.* towards *B.* 53. feete, wanting a tenth part of a foote, that is from *C.* to *M.* then meaſure from *M.* 45. feete towards *P.* alſo from *C.* 45. feete towards *P.* and where theſe two meaſures concurre namely at *P.* make a marke or drive a ſtake, then meaſure from *P.* to *D.* 45. feete, and from *C.* to *D.* 53. feete, lacking $\frac{1}{10}$ part of a foote, and where theſe two meaſures concurre as at *D.* there ſet a

ſtake



ſtake, meaſuring forwards towards *E.* till you have made *C E.* equall to *C B.* and that ſtanding at *E.* you may ſee the ſtakes *C.* and *D.* in a right line with your eye, then drive a ſtake at *E.* and in like ſort proceeding you may ſtake out the other three ſides.

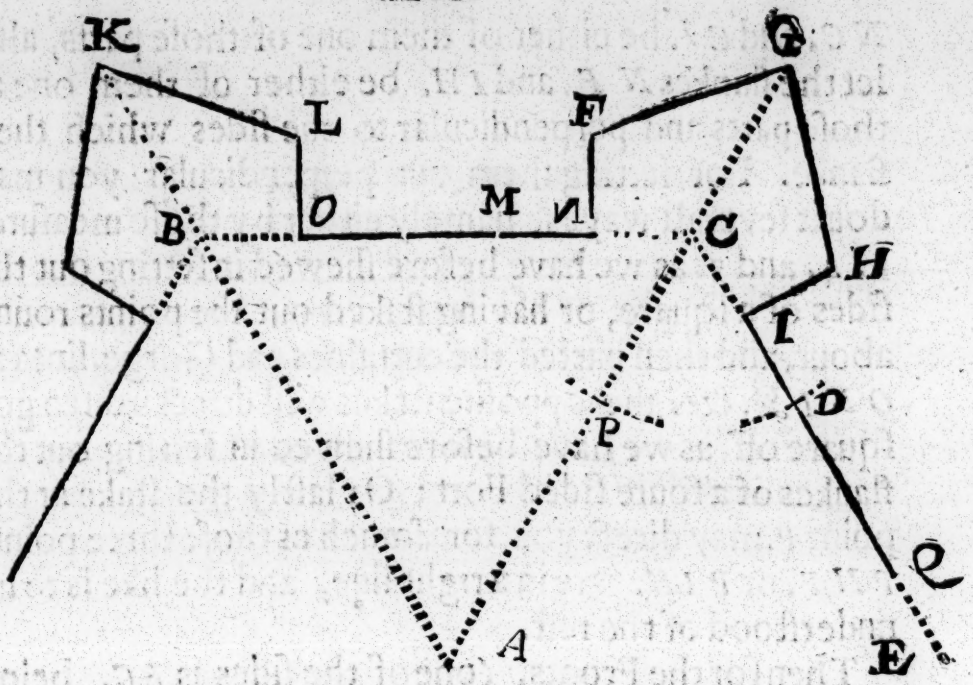
Then for the bulworkes, divide one of the ſides as *B C.* into five equall parts, and make the Gorge-lines as *N C.* and *C I.* to be either of them one of thoſe parts. Likewiſe let the flankes *N F.* and *I H.* be either of them one of thoſe parts, which flankes may be ſet ſquare or perpendicular to the ſides, which they flanke by the meaſures, 3. 4. 5. as we have before ſhewed. Laſtly divide one of the curtaines, as *O N.* into 5. equall parts, and meaſure from *F.* towards *G.* ſo much as 4. of thoſe parts come to, alſo from *H.* towards *G.* aſmuch, and where thoſe meaſures meete, as at *G.* there drive a

ſtake for the angular point of the bulworke, and the like is to be underſtood of all the other bulworkes. And thus the Gorge line *N C.* is a fift part of the ſide of the pentagon; the flanke *F N.* as much, the curtaine *O N.* three fift parts, and the fronts of the bulworkes *G F.* and *G H.* are either of them foure fift parts of the curtaine; ſo that if the ſide of the pentagon be 120. feete, (as ſo it may be, or more or leſſe) the Gorge line is 24. feete, the flanke as much, the curtaine 72. feete, and the fronts either of them 57 $\frac{3}{5}$ feete.

To ſet out a regular Skonce of ſixe ſides Mechanically.

YOu ſhall finde but few Skonces of ſixe ſides, but if you would ſet out ſuch an one, you may doe as followeth. Let *B C.* be the ſide of the Hexagon. Firſt then for ſetting out the other ſides, divide the ſide *B C.* into five equall parts, take with your chaine two of thoſe parts, as from *C* to *M.* and with that length of your chaine ſtrike an arch towards *A.* namely at *P.* then let one carry the end of the chaine from *C.* to *M.* and keeping it ſtill at the ſame length as before, note where it interſects the foreſayd arch which will be at *P.* there drive a ſtake. Alſo keeping ſtill the ſame length of your chaine, let one remove the end from *M.* to *C.* againe, and ſtrike the arch at *D.* then remove from *C.* to *P.* ſtriking on the ground the arch at *D.* keeping it ſtill at the ſame length as before, note how farre it reacheth in the arch before deſcribed at *D.* which will be to the point *D.* where drive a ſtake, and meaſure ſo from *C.* towards *E.* that the ſide *C E.*

may



may bē equall to *C B*. and that theſe 3. markes *C D E*. bē in one right line, and ſo you have two ſides of the Fort intended, namely the ſide *B C*. at the firſt given, and the ſide *C E*. thus laſt ſet out, and in like ſort you may ſet out all the other ſides.

The ſame ſides might alſo have bēene otherwiſe ſet out, by making *B A*. and *C A*. either of them equall to *B C*. (in this example onely) and ſo their concourſe at *A*. is the center of the Fort. Alſo meaſure the ſame diſtance from *A* to *E*. and from *C*. to *E*. ſo that theſe 3 lines, *C A*. *A E*. and *C E*. may be equall, the concourſe or meeting at *E*. is another corner, and the ſtreight line from *C*. to *E*. is another ſide, and in like ſort may all the ſides be ſet out.

Then for the bulworks. Whereas the ſide *B C*. is before divided into five equall parts; let the Gorge lines

N C. and *C I.* be either of them one of thoſe parts, alſo let the flankes *N F.* and *I H.* be either of them one of thoſe parts and perpendicular to the ſides which they flanke. For ſetting them out perpendicular you may doe it ſeverall wayes, namely either by thoſe meaſures 3. 4. and 5. as we have before ſhewed in ſetting out the ſides of a ſquare, or having ſtaked out the points round about, and then parted the curtaines and Gorge-lines as *O N I Q.* &c. the oppoſite ſtakes will direct you to goe ſquare off, as we have before ſhewed in ſetting out the flankes of a foure ſided Fort: Or laſtly the ſtake at the point *P.* may direct you, for aſmuch as thoſe three points *P N F.* or *P I H.* are in a right line, and the like is to be underſtood of the reſt.

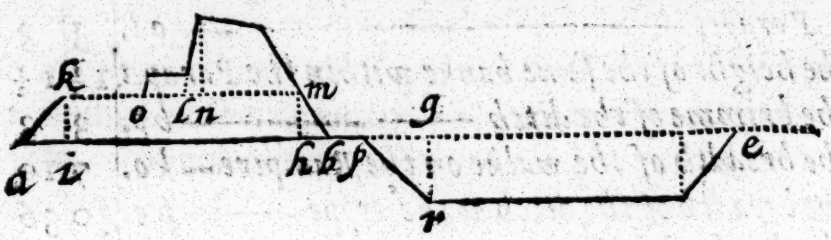
Then for the Fronts, (one of the ſides as *B C.* being as aforeſayd divided into five parts) meaſure from *C.* towards, *G.* two of thoſe parts for the head-line, and at the end of that meaſure drive a ſtake, ſo as you may ſee it in a right line with the ſtakes at *C.* and *P.* or *A.* and ſo is one of the bulworkes ſtaked out, and in like ſort you may ſtake out all the reſt.

And thus the Gorgeline *N C.* is a fift part of the ſide of the hexagon *B C.* and ſo alſo is the flanke *N F.* the curtaine *O N.* is three fift parts, and the head-line *C G.* is two fift parts, or two ſuch parts as the curtaine is three, ſo that if the ſide of the Hexagon *B C.* be 20. rods, or 200. feete, the Gorge-lines are every of them 4. rods, and the flankes as much; the Curtaines 12. rods, and the head-lines every of them 8. rods. But (as in this example) if the ſide *B C.* be but 120. feete, then the Gorge-lines are every of them 24. feete, the flankes

flankes asmuch, the Curtaines 72. feete, and the headlines 48. feete.

The Section or Profile of these Skonces.

THe height, breadth, and scarpings, of the Rampire, Parapet, Ditch, &c. of these Skonces, are represented in this Section. Thus *a b.* represents the breadth or thickenesse of the Rampire at the foote, which may be 24. 30. or 40. feete, the height thereof



i k. 4. 6. or 8. feete, and the inward Scarpe *a i.* asmuch, the outward Scarpe *h b.* 2. 3. or 4. feete, the breadth of the Parapet at the foote *l m.* 8. 10. or 12. feete, the brim of the ditch *b p.* may be three feete, or sometimes nothing at all. And so the rest of the measures such as by this ensuing table appeareth, wherein I have followed a late *Dutch* writer.

The

		Feete.		
The breadth of the Rampire at the foote —	a b.	24	32	40
The outward Scarpe of the Rampire —	h b.	2	3	4
The height of the Rampire —	i k.	4	6	8
The inward ſcarpe —	a i.	4	6	8
The breadth of the Parapet at the foote —	l m.	8	10	12
The inward Scarpe of the Parapet —	l n.	1	1	1
The height of the Parapet on the outſide —		4	4	4
The height of the Parapet inwardly —		6	6	6
The thickeneſſe of the Parapet at the toppe —		5	7	9
The breadth of the banke or footepace of the Parapet —	o l.	3	3	3
The height of the ſame banke within the Parapet		1 ½	1 ½	1 ½
The brimme of the ditch —	b p.	3	3	3
The breadth of the walke on the Rampire —	k o.	7	10	13
The breadth of the ditch at the toppe —	p e.	30	36	54
The depth of the ditch —	g r.	6	6	8
The Scarpe of the ditch —	p g.	6	6	8
The breadth of the ditch at the bottome —		18	24	38

In theſe I have expreſſed no Covert way without the ditch, which notwithſtanding you may make if you pleaſe, and if the ditch be not full of water, you may take away the edge thereof at *e* 1 ½. foote deepe, and about 3. or 4. foote broad round about, then leaving 4. or 5. foote breadth further out, you may thereraiſe the Parapet of the Covert way, 4. or 4 ½. foote high.

In rayſing the Rampire, at the foote thereof on the outſide

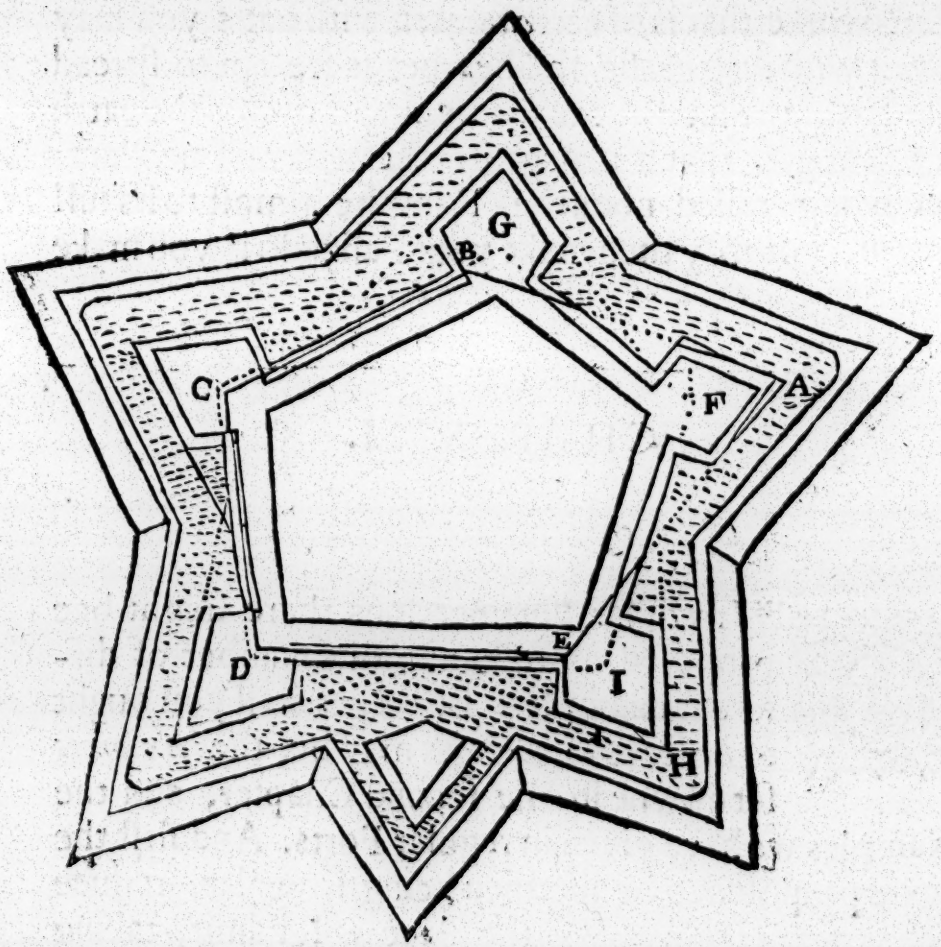
outside you may plant young Willowes, Haw-thorne bushes, and other such like, and bring up the face of the Rampire with turfes, and when the Rampire is one foote high, it must be beaten and stamped downe till it come to 8. or 9. inches, that it may settle no more, and when the face is rayſed five rankes of turfe, you may plant other young Willowes or bushes, (especially if the earth be sandy) and sow Oates and Hay seed chiefely such seede as hath a strong spreading roote, betweene every ranke of turfes, that the rootes may knit and fasten the turfes together. And so if the face be of platt-worke, that is of earth beaten with batts, you may sow it with such grasse and hearbes as are apt to spread and cover the face of the worke, and moysten the earth in platting it, that it may grow the better. The Parapet being raised upon the Rampire almost to its full height, you may then make your Palizado if you make any, &c.

CHAP. XIII.

Of Irregular Fortification.

OF Irregular Fortifications there might bee proposed, almost an infinite number of different examples. But in generall you ought to observe so neere as may be, the *Axiomes* set downe in the second Chapter, and the examples we have given in regular Forts. And first the figure proposed to be fortified being irregular, reduce it to as much regularity as the place will admit, taking

in and leaving out here and there a little, to make some neere equality of the sides and angles. Then if any angle of your figure be lesse than 90. degrees, you are not to set a bulworke on that angle, but rather to make that angle, to be the flanked angle of a bulworke, diminishing it somewhat if occasion require. And for the other angles of your irregular figure, you are to fit bulworkes so, as the flanked angle of the bulworke may be answerable to the angle of the Poligon whereon it stands, according to either of the two rules before gi-



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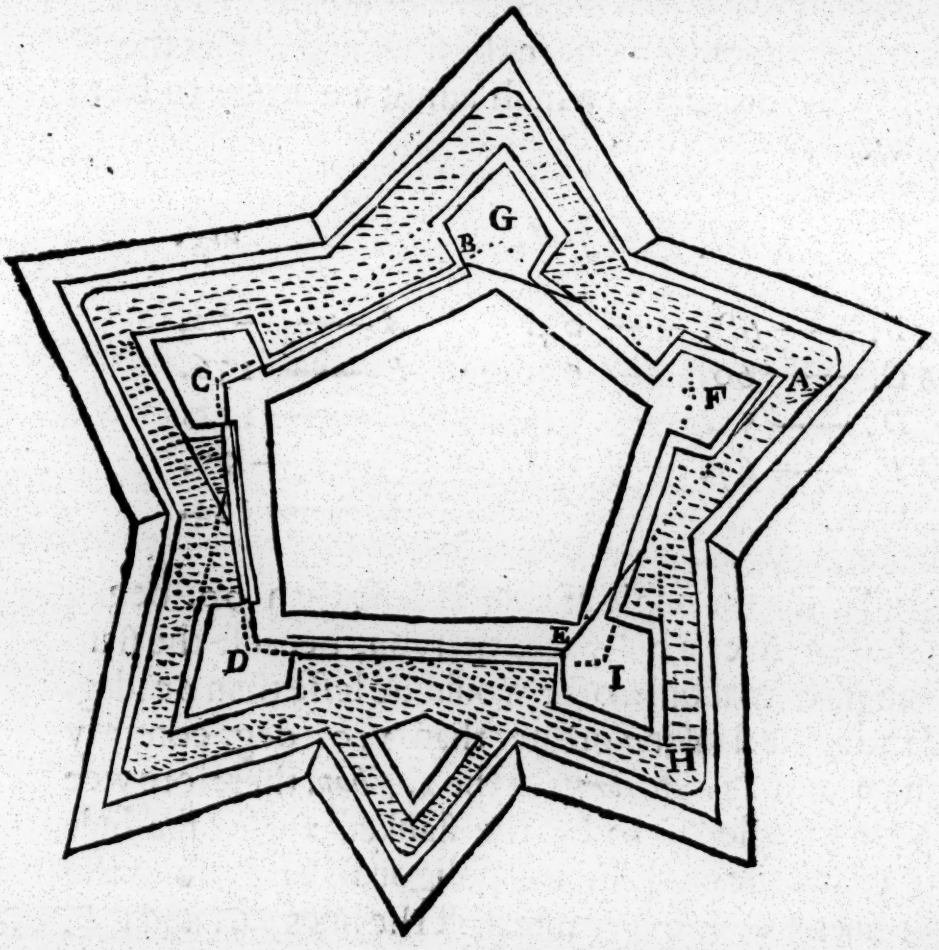
ven *Chap.* 4. That is first, unto halfe the angle of the poligon figure, adde 15. deg. the summe is the flanked angle of the bulworke: Or otherwise take two third parts of the angle of the poligon, for the flanked angle of the bulworke to be thereon placed; Yet is ⅔ of that angle to be more than 90. d. but it may suffice to make the angle of the bulworke onely 90. d. Take this example which I have here set downe almost in the same manner as is done by *Sa. Marolois* in his booke of Fortification.

Let *A B C D E.* be an irregular pentagon to be fortified with such bulworkes as may be suteable to the angles of the figure. First then the sides and angles thereof are to be measured, which admit we finde to be as followeth.

	rods.	*feet.*		*deg.*
A B.	68.	04.	*A*	72.
B C.	60.	00.	*B*	136.
C D.	55.	02.	*C*	111.
D E.	67.	02.	*D*	97.
			E	124.

And seeing the angle at *A.* is lesse than 90. deg. it is not fit to place a bulworke thereon, because the flanked angle of that bulworke would be lesse than 60. deg. and the angle flanking greater than 150. deg. contrary to the 9. and 11. *Axiomes* of the 2. *Chap.* therefore wee make that angle *A.* to be the flanked angle of a bulworke, and the angle of the poligon to be *F.* so as the right lines *F G.* and *F I.* intersect the lines *B C.* and *C E.*

in the points *G.* and *I.* upon which angles, and according to the proportion of the ſides we deſcribe the bulworkes, alwayes obſerving that the angle of the poligon ſheweth of what kinde the bulworke thereon ſet muſt be, whether of a Pentagon ſquare or Hexagon: proportionating the parts of the bulworke, according to the leſſer of the two ſides, and ſo will that figure be fortified as here appeareth. And becauſe the ſide *D E.* being drawne forth to *I.* is longer then the rules and proportions before ſet downe in regular figures will ad-



mit

mit of, it will bē neceſſary betweene the two bulworkes *D.* and *E.* to make a Ravelin, as here appeareth; ſuch that the fronts thereof may be ſcowred and defended from the flankes and fronts of thoſe two bulworkes, and ſo that angle will be more or leſſe, according to the length or ſhortneſſe of the cuttaine, and the fronts of this Ravelin may be either of them 22. or 24. rods, or ſomething more or leſſe, as the place and ſcituation ſhall require. And for your better underſtanding of mine intention, in the fortification of places irregular ſuch whoſe angles are not leſſe than 90. deg. which is the angle of a ſquare, and their ſides not much different from thoſe of regular figures; you may doe thus.

Let it be required to Fortifie the angle *C.* being an angle of 111. deg. which is neere unto the angle of a pentagon. According to which take the ſhorteſt of the two ſides, *BC.* and *CD.* which is here *CD.* containing 55. rods, or 552. feete, ſearching alſo in the foregoing Table of the demenſions of regular Fortifications, for the demienſions appertaining to a Pentagon, and then ſay by the rule of proportion

As the ſide of a Pentagon being ——	66.36.	6,17810.
hath to the front of the bulworke ——	28.00.	3,44716.
ſo the ſide of a Pentagon being ——	55.02.	3,74052.
may have the front ——————	22.30.	3,36578.

And thus we finde the front for ſuch a bulworke to be 23. rods, 2. feete, and two tenths of a foote, ſo according to this example you may in like manner finde by the rule of proportion, the flanke and Gorge-line, and ſo all the lines and angles in this bulworke *C.* as

alſo thē othēr parts of this whole Fort. Holding it alwayes for a certaine rule that the angles of a Poligon to be fortified muſt be at the leaſt right angles, and if there be any angle leſſe than a right angle, you may make that the flanked angle of a bulworke, inlarging or leſſening it ſomewhat, if occaſion require, till it become a competent angle for ſuch a bulworke. And if the ſides of the poligon propoſed, doe exceede the ſides of the inward Poligons, ſpecified in the foreſayd Tables, we may make them as ſides of the outward Poligons, and trace out the Fort within them, and that according to the ſpecies of every ſeverall angle *F G C D I.* and ſo ſhall the figure propoſed be fortified.

If you deſire more examples touching the Fortification of places irregular, you may peruſe *Sam. Marolois* his booke of Fortification, thus much at preſent may ſuffice.

FINIS.

ERRATA,

PAge 3. line 24. for Coverat reade Covert. p. 11. l. 3. for C. r. D. l. 17. r. 6,04 18290. p. 29. l. 5. r. 7,71541. p. 36. l. 10. for R r. O. p. 44. l. 15. for C. r. H. p. 67. l. 4. for NO N r. NOW. p. 95. l. 4. r. face. p. 100. l. 2. for n. r D.